THURSDAY, SEPTEMBER 9, 1886

## THE ECLIPSE EXPEDITION

NOTHING could have exceeded the magnificent manner in which the authorities of Grenada, and chiefly His Excellency Governor Sendall, and the commanders of the ships detailed to assist the Expedition—Her Majesty's ships *Fantôme*, *Bullfrog*, and *Sparrowhawk*—have met the wishes of, and lent assistance to, the Expedition.

As a consequence, at this time of writing (August 20) all the observers, with the exception of the Chief of the Expedition, are at their posts, with huts and instruments erected, and as much skilled assistance as they can possibly desire. The stations actually occupied so far are as follows:—

(1) Carriacou. Rev. S. J. Perry and Mr. Maunder. This party has the *Bullfrog*, two officers of which will assist, as well as Lieut. Helby of the *Sparrowhawk*.

(2) Boulogne. Prof. Tacchini and Mr. Turner. Lieut. Smith, of the *Sparrowhawk*, and a petty officer and skilled artificer, assist this party.

(3) Hog Island. Prof. Thorpe. The *Fantôme* is anchored near the observing-station, and Prof. Thorpe will have the assistance of the officers.

(4) Prickly Point. Capt. Darwin and Dr. Schuster. One or two officers of the *Fantôme*, and Capt. Maling, the Colonial Secretary, assist this party.

The fifth station, to be eventually occupied by Mr. Lockyer, is at Green Island, at the north-east corner of Grenada. Capt. Oldham, of the *Sparrowhawk*, Mr. Beresford (the Clerk of the Council), the Chief of the Police, Mr. Wright, and Dr. Boyd will assist him.

The parties at Boulogne, Prickly Point, and Green Island occupy houses which have been placed at the disposal of the Expedition by Col. Duncan, Mr. Chadwick (the Treasurer of the Island), and Mr. Belton respectively; nothing can exceed the kindness which the Expedition has received, and the assistance rendered has been so effectual, that so far everything has gone without a hitch. The labours of the Governor in the cause of the Expedition have been unceasing; he planned a hut and sent a model to Barbados, and when it was approved (by telegraph) he had four ready awaiting the arrival of the parties, which were thus enabled to proceed at once to their stations.

The weather chances are doubtful, but certainly they have improved since the arrival of the Expedition. The observations of the local cloud conditions have been so continuous lately, not only by the observers themselves, but by many at the request of the Governor before the arrival of the Expedition, that there is no question that the best stations are occupied, and it is a matter of general satisfaction that Carriacou has been added to the line of stations. The local idea is that the hurricane which passed over St. Vincent—and so nearly over Grenada!—last Monday has cleared the air, as it has been noticed that spells of fine weather generally follow them.

The *Fantôme* comes in on Sunday to convey the Green Island party to their station; although this will leave very little time for the party to establish itself, it has been considered desirable to leave the southern observers undisturbed as long as possible. The Governor and Mr. Lockyer will proceed in her to Carriacou to inspect the station there, while the hut and instruments are being erected at Green Island. The last week has been spent here in erecting and dismounting the instruments and overhauling everything, so that no time will be lost at the station itself.

There are photographic difficulties ahead: with the ordinary plates brought out here, the film simply disappears in the developer in consequence of the usual temperature of the water, about 80°. The Germans and Americans are now supplying plates here which stand this temperature easily, but they do not seem to be known in England. It looks very much as if it will be safer to take some if not all of the photographs obtained—if any *are* obtained—to be developed at home.

The Expedition will arrive in England on September 18.

St. George, Grenada

## THE ZOOLOGICAL RESULTS OF THE "CHALLENGER" EXPEDITION

*Report on the Scientific Results of the Voyage of H.M.S. "Challenger" during the Years* 1873-76 *under the Command of Capt. G. S. Nares, R.N., F.R.S., and Capt. F. T. Thomson, R.N.* Prepared under the Superintendence of the late Sir C. Wyville Thomson, F.R.S., &c., and now of John Murray, one of the Naturalists of the Expedition. Zoology—Vol. XIV. By Prof. W. A. Herdman, and Hjalmar Théel. (Published by Order of Her Majesty's Government, 1886.)

VOLUME XIV. of the Zoological Series of these Reports contains Parts 38 and 39. Part 38 forms the second part of Prof. W. A. Herdman's Report on the Tunicata collected by the Expedition. It will be remembered that the first part was published in 1882, and that it treated of the Simple Ascidians. The Compound Ascidians are described in the present Report, and the free-swimming or pelagic forms will form a third and concluding Report. The Compound Ascidians have always been regarded by biologists as a most difficult group to describe. The impossibility of finding good diagnostic characters in external markings or general contour compels the investigator to search for such in minute internal structure—a laborious proceeding, and one that up to this had had no practical illustration. The large collection of Compound Ascidians made during the Expedition represented 102 species or well-marked varieties, and these are arranged in twenty-five genera. Eighty-eight of the species and ten of the genera are described here for the first time, and two new families have been established.

The families and genera seem to be uniformly distributed, but they are more numerously represented in the southern than in the northern hemisphere; indeed, the Compound Ascidians, like the Simple Ascidians, attain their greatest numerical development in the southern temperate zone. The Botryllidæ appear to be confined to the northern hemisphere, having there a very wide range. The Distomidæ are well represented in both hemispheres. The Polyclinidæ almost exclusively belong to the

southern hemisphere. The Diplosomidæ are from tropical seas. The family of the Cœlocormidæ is only known from the southern hemisphere. In the Didemnidæ the genera are well represented in both hemispheres, while in that of the Polystyelidæ the southern and northern forms belong to different genera.

The Compound Ascidians are not deep-sea forms. While between shore-mark and a depth of 50 fathoms over 60 species and varieties were found, but 12 species were met with at depths between 100 and 250 fathoms; 4 species extended to a depth of 500; 7 species to a depth of 1000 fathoms; and one strange form, *Pharyngodictyon mirabile*, was found at a depth of 1600 fathoms. While as a matter of course the shallow-water forms have been better known from being so much more easily collected than the deep-sea species, still Prof. Herdman seems amply justified in his conclusions that the Compound Ascidians are essentially "a shallow-water group, that they are abundant around coasts in a few fathoms of water, and that they rapidly decrease in numbers as greater and greater depths are reached."

As to the phylogeny of the group, the author has come to the conclusion that the Compound Ascidians are polyphyletic in origin, being made up of several branches which at differing periods have arisen from the Simple forms.

As introductory to the description of new genera and species, we find a very complete and most instructive chapter devoted to the history, bibliography, and anatomy of the group. The general anatomical details are illustrated by some excellent woodcuts. The details of the anatomy of the various species are given in connection with their description, and are largely illustrated on the forty-nine plates drawn by Prof. Herdman which accompany the memoir. The investigation of the Ascidians, despite the existence of some few brilliant memoirs, is now for the first time done justice to; and, while we congratulate the author on his excellent work, we recognise in it not only an elaborate Report, but in addition a monograph of a, to this, very imperfectly known group.

Part 39 is a Report on the Holothuroideæ, by Hjalmar Théel, Part 2. In the second portion of this Report on these soft-bodied Echinoderms, Théel has not rested satisfied with giving a description only of the new forms of the groups Apoda and Pedata, which were brought home by the Expedition, but he has added a series of short accounts of all the forms known, even quoting the doubtful or little-known forms. Thus we have in this report also a veritable monograph of another most interesting group. Although unable to say much as to the bathymetrical distribution of these forms, still the *Challenger* dredgings have added many facts to our previous knowledge. Up to 1872 very few forms were known from depths exceeding 100 fathoms, and scarcely one from below 200 fathoms. Now we know of a number of forms met with at a depth of 500 fathoms, and these are generally distinct from shallow-water forms though belonging to the same genera. Several species have a vast bathymetrical distribution, some individuals still living near the shore, while others have descended without any notable change to depths of from 5 to 700 fathoms. Some few belong to genera that have no representatives in depths shallower than 500 fathoms. Among the very deep-sea forms we find *Cucumaria abyssorum*, at a depth of from 1500 to 2223 fathoms; *Synapta abyssorum*, at a depth of 2350 fathoms; *Pseudostichopus villosus*, at a depth of 1375 to 2200 fathoms; and the deepest-living of all the forms, *Holothuria thomsoni*, at a depth of from 1875 to 2900 fathoms. Some fifty-three new species or strongly-marked varieties are described and figured. A valuable bibliography is annexed Many imperfectly-described species have been re-described from fresh specimens, thus rendering this Report of immense value to the working zoologist.

## OUR BOOK SHELF

*Miscellaneous Papers relating to Indo-China.* 2 Vols. Trübner's Oriental Series. (London: Trübner and Co., 1886.)

IN Oriental matters, more than in any other branch of investigation, the student is beset at every step by the difficulty of knowing what has been done already, for, besides books and papers published in London and other European capitals (which are accessible enough), there are those published in the East itself by numerous Societies as well as private individuals. In addition, many of the *Journals* and *Proceedings* of Societies to which the student would desire to refer are long since out of print, and many of them fetch a very high price indeed. Such are the *Chinese Repository*, the *Oriental Repertory*, Logan's *Journal of the Indian Archipelago*, and many others that could be named. In London these can be consulted at the British Museum, at the libraries of the India Office and the Royal Asiatic Society, and perhaps elsewhere; but this is of little service to the student elsewhere in the British Islands, and still less to one who is working in the very field itself, in the Malay Peninsula, Java, Borneo, Bangkok, or China. Occasionally, an enterprising Society or publisher may republish some of these old papers, but this is not often done, for the number of immediate buyers is necessarily small, and the return therefore slow and doubtful.

Recent events in various parts of Further India, including in this term that part of Asia west of Burmah and south of China, have attracted the public mind to these regions. Accordingly, the Straits Branch of the Royal Asiatic Society, which has its seat at Singapore, decided to publish a first instalment of papers relating to Indo-China, but mainly to the Malay Archipelago, scattered about in various periodicals now beyond the reach of most students, and out of the question for those who are unable to consult large libraries. A selection of papers was made by officers of the Society in Singapore; these were carefully edited by Dr. Rost, the Librarian of the India Office, and the work was fortunate in being placed in Messrs. Trübner's Oriental Series—a series of works which, whether we regard individual excellence or the range of Oriental knowledge which it embraces, stands unrivalled in the world, for in every direction it forms the high-water mark of European study of the East. The present volumes include selections from the papers published in Dalrymple's *Oriental Repertory*, the old *Asiatic Researches*, and the *Journal* of the Asiatic Society of Bengal. It may be hoped that the Society will feel able and willing to continue the issue of similar selections from other sources. The papers commence about 1808, and the latest are dated about 1860, and they embrace almost every subject of interest relating to the East. Some of the earlier reports are now of merely historical interest, such as Topping's account of Keddah, Barton's surveys and description of Balambangan, and the history of the formation of the East India Company's establishment at Penang. But others are of more value. There are numerous descriptions of various economic products, as

the gum vine of Penang, the caoutchouc vine of Sumatra, and metals in the Malay Peninsula. In philology and ethnology we have a paper on traces of the Hindu language amongst Malays (by Marsden); Dr. Leyden's famous paper on the languages and literature of the Indo-Chinese natives, the alphabets of the Philippine Islands, &c. There are several papers on geology and natural history. Two of the latter are catalogues of the Mammalia and reptiles inhabiting the Malay Peninsula, by Dr. Cantor; while a third is a catalogue of the botanical collection brought home by the same naturalist in 1841. Another paper re-published has a peculiar interest, in view of the surveys undertaken by the French two years ago in the Krau isthmus for the purpose of cutting a canal. This is a report by Capts. Fraser and Forlong on a journey from the mouth of the Pakchan River to Krau, and thence across the isthmus to the Gulf of Siam. In the 16th paragraph of that report they urged that the Bay of Bengal could be connected with the China Sea by cutting through the isthmus at comparatively little expense. They enter into calculations showing how easily this could be done, the advantages of the route, &c. These calculations of distance, cost, &c., are exceedingly elaborate, and show that the two officers entered thoroughly into the matter.

It will thus be seen that the volumes offer much of interest to several classes of students, and we repeat the hope that the Singapore Society may shortly be in a position to continue the publication of further selections.

## LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to insure the appearance even of communications containing interesting and novel facts.*]

### Physiological Selection and the Origin of Species

SEEING that criticisms on the theory of physiological selection are flowing through channels other than the pages of NATURE, and this in a volume larger than could at first have been anticipated, it seems desirable that I should now permit them to exhaust themselves before undertaking a further and a general reply. On the present occasion, therefore, I will only ask you to be good enough to insert the following remarks.

In order to put myself right with my critics, I should like them to remember that the paper published by the Linnean Society is designedly restricted to a preliminary statement of principles, which, it was hoped, might fulfil its avowed object of inducing other naturalists to co-operate with me in verifying the theory by observation and experiment, in the ways suggested. Such being the design, all details as to facts and references were intentionally omitted, and the same has to be said for all objections to the theory which had occurred to my own mind. All these things will require to be gone into with the utmost care, should the course of verifying inquiry eventually prove that the voice of Nature pronounces for the theory. Therefore, while I shall be thankful for all criticisms, I should like my critics to remember that they have not as yet my whole case before them. In particular, I may intimate that I should not have published even the outlines of my theory had I not been prepared for the very obvious exceptions which are taken to it by Mr. Wallace in the current issue of the *Fortnightly Review*.

I am much indebted to Mr. Francis Darwin for his reference to Mr. Belt's anticipation of my theory, for the fact that in its general form this theory has independently occurred to so distinguished a naturalist, appeals to me as an additional pledge of its probability. On the other hand, I am greatly disheartened by his further statement that he has reason to suppose his father was "familiar with the principle of physiological selection," and yet "did not regard it with any great favour." Hitherto I have been under the impression that it was a theory to which the judgment of his father would probably have inclined, and therefore I shall await with no ordinary interest the statement of his reasons for thinking otherwise, whether this be communicated through your columns or privately to myself. It only remains to add that, if Mr. Darwin will be kind enough to turn to p. 380 of my paper, he will find that I have quoted *in extenso*, and with its context on both sides, the passage from the "Origin of Species" which he extracts. But it does not appear to me that this passage furnishes any evidence that the theory of physiological selection was ever present to the mind of the writer—less evidence, for instance, than there is from a passage in one of his earliest writings that the theory of natural selection was present to the mind of Mr. Herbert Spencer.

GEORGE J. ROMANES

Geanies, Ross-shire, September 4

### Actinotrocha of the British Coasts

I HAVE been reminded by Mr. T. Bolton, of Birmingham, that about three years ago I sent him living specimens of what Mr. A. G. Bourne afterwards identified as *Phoronis*. At the time I was under an impression, from hasty observation of the arrangement of the tentacular crown, and before I had seen the entire animal, that I had found a new Polyzoan allied to *Lophopus*. *Phoronis* occurs here in company with *Spio seticornis*; a solitary individual or a small group of the former, in the midst of a colony of the latter. A block of stone densely populated with these annelids is a most interesting object in a tank. To me they have proved so interesting that I believe I have spent more time over them than over any other marine organism.

I take the opportunity of calling attention to what I believe is an undescribed species of *Peridinium* that annually recurs in these waters. The form is flattish, and the outline bi-conical, having one end bifurcated, with a flagellum in the fork, and a central ciliary groove. By degrees it loses its present form, and assumes that of a spheroid.

I will gladly send specimens of either or all of these organisms to any naturalists who may wish to study them, if the cost of carriage be defrayed and the applicants not very numerous.

Sheerness-on-Sea W. H. SHRUBSOLE

### A New Aërolite

ON May 28 last a farmer of Barntrup, a small town of the Principality of Lippe, in the north-west of Germany, walking in the afternoon, 2h. 30m., on the edge of a neighbouring wood, suddenly heard repeated reports like those of a gun, followed shortly after by an indistinct rumbling as of thunder. At the same time a meteorite came crashing through the leaves of a tree. The rumbling came from a south-westerly direction, the temperature was warm, the sky bright, and almost entirely cloudless.

This is the twelfth case of a meteoric fragment being found in the north-west of Germany. It is a monolith of about the size of a walnut, and weighs 17·3 grammes (specific weight = 3·495). It is covered with a black crust chipped off in places by the fall. Under this crust it is of a light gray colour and granitic substance, dotted in places with small yellow crystals, which are probably troilite or schreibersite. It has been lately presented to the Detmold Museum. L. HAEPKE

Bremen, Germany

## DRAPER MEMORIAL PHOTOGRAPHS OF STELLAR SPECTRA EXHIBITING BRIGHT LINES

THE spectra of ordinary stars, whether examined directly by the eye, or indirectly by means of photography, present little variety. The comparatively few cases of deviation from the usual type are therefore particularly interesting, and the occurrence of bright lines in a stellar spectrum constitutes perhaps the most singular exception to the general rule. The brightness of the F line in the spectra of $\gamma$ Cassiopeiæ and $\beta$ Lyræ was noticed by Secchi. Rayet afterwards found three rather faint stars in Cygnus, the light of which was largely concentrated in bright lines or bands. The adoption at the Harvard College Observatory of a system of sweeping, with a direct-vision prism attached to the eye-piece of the

equatorial telescope, resulted in the discovery by the present writer of several additional objects of the same class. Still more recently, Dr. Copeland, during a journey to the Andes, has extended the list by the discovery of some similar stars in the southern heavens.

Among the photographic observations which have been undertaken at the Harvard College Observatory, as a memorial to the late Prof. Henry Draper, are included a series of photographs of the spectra of all moderately bright stars visible in the latitude of the Observatory. A recent photograph of the region in Cygnus, previously known to contain four spectra exhibiting bright lines, has served to bring to our knowledge four other spectra of the same kind. One of these is that of the comparatively bright star P Cygni, in which bright lines, apparently due to hydrogen, are distinctly visible. This phenomenon recalls the circumstances of the outburst of light in the star T Coronæ, especially when the former history of P Cygni is considered. According to Schönfeld, it first attracted attention, as an apparently new star, in 1600, and fluctuated greatly during the seventeenth century, finally becoming a star of the fifth magnitude, and so continuing to the present time. It has recently been repeatedly observed at the Harvard College Observatory with the meridian photometer, and does not appear to be undergoing any variation at present.

Another of the stars shown by the photograph to have bright lines is D.M. $+ 37° 3821$, where the lines are unmistakably evident, and can readily be seen by direct observation with the prism. The star has been overlooked, however, in several previous examinations of the region, which illustrates the value of photography in the detection of objects of this kind.

The other two stars first shown by the photograph to have spectra containing bright lines are relatively inconspicuous. The following list contains the designations according to the *Durchmusterung*, of all eight stars, the first four being those previously known:—35° 4001, 35° 4013, 36° 3956, 36° 3987, 37° 3821, 38° 4010, 37° 3871, 35° 3952 or 3953. Of these 37° 3871 is P Cygni, and 37° 3821, as above stated, is the star in the spectrum of which the bright lines are most distinct.

EDWARD C. PICKERING

## *PEAT FLOODS IN THE FALKLANDS*

THE accompanying narratives of a singular visitation which has befallen the town of Stanley in the Falklands may be of some interest to the readers of NATURE. Though the causes are so different, the effects of the bursting of a peat-bog in some respects curiously simulate those of a lava-flow. The papers have at different times been sent to Kew from the Colonial Office. It is partly in the hope that their publication may lead to some practical suggestion for dealing with the trouble that I ask for their insertion in your columns.

W. T. THISELTON DYER

### THE ACTING-GOVERNOR BAILEY TO GOVERNOR CALLAGHAN, C.M.G.

*Stanley, Falkland Islands, January* 1, 1879

SIR,—I regret to have to report to you the circumstances attending an accident which happened early on the morning of November 30 last.

Just after midnight on Friday, November 29, one of the inhabitants was awakened by the continued barking of his dog, and thinking that a cow had strayed into his garden, he went outside, when to his alarm he found that his house was surrounded by a black moving mass of peat several feet in height, and travelling down the hill at about four to five miles an hour. It was not until daylight that the extent of the disaster was manifested.

The sufferers by the calamity were quite shut off from communication with the rest of the settlement, until they had cut a way for themselves through the heap of liquid peat, which everywhere surrounded their dwellings. Fortunately no lives were lost.

Immediately, when the report reached me, I proceeded to the scene of the disaster, and found the town in a worse state than it had been represented, all communication between the east and west end of Stanley being entirely cut off, except by boats. At this time there was no perceptible movement in the mass of peat which covered the ground in confused heaps, except in Philomel Street and the drain on the east side—where I perceived the liquid peat moving down at a very slow rate. To get rid of this as quickly as possible, I found it advisable to turn all the water that could be damned up, and sluice the peat whilst in a liquid state, and by this means I eventually cleared Philomel Street. On following up the course which the slip had taken, the hill presented a curious appearance. From the peat bank, down to the brow of the hill, a distance of about 250 yards, the surface-peat lay in confused heaps direct from the opening of the bog. The moving power (whether water or liquid peat it is impossible to say) travelled over the ground faster than the heavier bodies, which were left standing 3 to 4 feet above the level of the ground.

Proceeding to the top of the bog, I found a depression extending over 9 to 10 acres of ground, the edges cracking and filling up with water, and threatening another accident. I at once saw the necessity of calling upon the inhabitants to assist me in cutting a trench at the back of the hill, so as to draw off this accumulation of water, which seemed likely to float the loose peat left in the depression down into the settlement. I am glad to say that this call was heartily responded to by every man in the settlement, the gentlemen finding substitutes to take their places.

All worked for eight days in the cold and the rain, but nevertheless they were unsuccessful in carrying the trench through the bank into the bottom of the slip, owing to the soft peat welling up from the bottom and filling the trench again. Seeing that the exertions were of little avail in the present state of the bog, I did not press the settlers to continue the work that was so disheartening in its results; and as I now felt satisfied, from the great quantity of water that had been drained off, and the cutting being at a level, that this would prevent any further accumulation of water taking place in the slip, as there was no immediate danger of another accident taking place, the work was stopped, and I published the inclosed notice.

With your Excellency's permission I will, in the course of a few weeks, prepare sections of the bog and the settlement, showing a plan of drainage which will, I hope, prevent a similar accident happening again.—I have, &c.,

(Signed) ARTHUR BAILEY

His Excellency Governor Callaghan, C.M.G.

### LIEUT.-GOVERNOR BARKLY TO EARL GRANVILLE

*Government House, Stanley, Falkland Islands, June* 3, 1886

MY LORD,—I regret to have to report that a slip of the peat-bog at the back of the town of Stanley, similar to that which occurred in November 1878, but about 200 yards to the westward of the scene of that accident, took place last night. A stream of half-liquid peat, over 100 yards in width and 4 or 5 feet deep, flowed suddenly through the town into the harbour, blocking up the streets, wrecking one or two houses in its path, and surrounding others so as completely to imprison the inhabitants. Fortunately, as the night was wet and stormy, almost every one was within doors, and the few who were in the wrecked houses escaped in time. One child was, unfortunately, smothered in the peat, whose body has been recovered, but no other casualties are known to have occurred. An old man is, however, reported to be

missing this morning, and it is feared he may also have perished, as part of his house is almost filled with peat.

(2) The people of Stanley, as on the former occasion, showed great energy and resource in dealing with the danger, and before I myself reached the spot barriers had been erected and lanterns placed to keep the public from dangerous spots, whilst all those who had been driven from their homes had been accommodated by their neighbours.

(3) This morning bodies of volunteers were early at work, clearing the streets, so far as it was safe to do so without risk of disturbing the superincumbent mass of peat and setting it in motion again, and draining the water from it as far as was practicable. I have also employed a strong body of labourers, under experienced supervision, in the same work, and have directed the removal of all persons remaining in dangerously situated houses; and there is now little risk of further accident.

(4) The slip was caused, apparently, by the unusually heavy rains which have fallen during the last few days, and which the drains constructed by Mr. Bailey, the Surveyor, in 1878, proved insufficient to carry off. Deeper and wider cuttings will now be made, and I trust that the recurrence of any similar catastrophe may thus be prevented. The town of Stanley is, however, from its situation and the mass of peat-bog on the high ground behind it, always to some extent exposed to danger of this nature in times of unusually heavy rainfall.—I have, &c.,

(Signed) ARTHUR BARKLY

The Right Hon. Earl Granville, K.G., &c.

## THE BRITISH ASSOCIATION

BIRMINGHAM, *Tuesday*

THE Birmingham meeting has been one of unusual excitement, mainly originating in the pre-arranged discussions which have taken place in several of the Sections. It is generally felt that this comparatively new feature has given new life to the Association, and ought to become general in all the Sections. At present the arrangements are somewhat crude, and the discussions are apt to become unmanageable. In some cases each of the speakers has all he means to say already written out, so that the discussion becomes merely the reading of a series of papers on a given subject. In other cases, however, at the present meeting, the discussions have been to a large extent extemporaneous. This was especially so with the joint meeting of Sections A and D to consider the subject of colour-vision, and with the discussion in Section E on Geographical Education. Probably the most lively and generally interesting discussion was that which followed Mr. Seebohm's paper on Dr. Romanes' theory of Physiological Selection. Among those who took part in this were Profs. M. Foster, Newton, and Francis Darwin. On Saturday there was a lively and instructive discussion in Section C on Pre-Glacial Man, in which Prof. McKenny Hughes, Mr. Pengelley, Prof. Boyd Dawkins, Mr. De Rance, and others took part. The address of the President, Sir William Dawson, was a great popular success, so far as he could be heard. Prof. Rücker's lecture on soap-bubbles was universally admired, the experiments being unusually brilliant. Prof. Roberts-Austen's lecture to working men, on Saturday night, on the colour of metals, was greatly appreciated by a crowded audience.

The weather has not been so good as could have been wished, so that the excursions and garden parties have been somewhat damped. The *soirée* in the highly interesting Industrial Exhibition at Bingley Hall on Thursday evening was crowded and successful. Indeed the arrangements throughout made by the Local Committee for the entertainment of visitors have given complete satisfaction; the comfort and convenience of the visitors having been provided for in every conceivable way.

At the meeting of the General Committee yesterday, it was resolved to accept the invitation to Bath for 1888. For the Manchester meeting of next year, Sir Henry Roscoe was chosen President, the meeting to begin on Wednesday, August 31. The fact of an invitation having been sent from New South Wales for 1888, has been already noticed in NATURE. The invitation came up for consideration yesterday, with the result that it was decided to send a deputation of forty or fifty representative members of the Association, to be selected by the Council in co-operation with the Sectional Committees. The New South Wales Government have offered to pay all the expenses of such a deputation, but they insist, in somewhat dictatorial terms, that the deputation shall consist only of the most eminent representatives of British science. This subsidiary meeting will take place in Sydney in January 1888, when it is hoped representatives of science from all the Australasian colonies will assemble, and with the deputation hold a meeting, which will have for its object the promotion of science in Australia, and of more intimate relations between its representatives there and here. On the return of the deputation to this country it will report its proceedings to the Bath meeting; for the Australian meeting will not be regarded as a regular meeting of the British Association. On the whole, the decision come to at the General Committee meeting appears to give satisfaction. Victoria has also sent an invitation, but agreed to retire in favour of its sister colony.

The number attending the Birmingham meeting is about 2500.

Dr. MacAlister read on Thursday last to Section A a communication from the Grenada Eclipse Expedition, announcing that excellent photographs had been taken of the eclipse, and that successful experiments with the spectroscope had been made in the northern part of the expedition by Dr. Schuster, Capt. Darwin, and Prof. Thorpe. Dr. Schuster obtained two good and two fair photographs of the corona. Good spectra of the solar prominences have been obtained, showing the bright lines of highly incandescent vapours. In this respect the result resembles that obtained in the two previous eclipses, though it was thought possible that this year, being one when sunspots are tending to a minimum, would be marked by the more continuous spectrum that bespeaks lower temperature. The bright lines were especially well marked when the slit of the spectroscope was tangential to the sun's disk, less marked when the slit was radial. Capt. Darwin was in charge of the coronagraph, an instrument by which a continuous series of photographs of the corona, before, during, and after totality, can be taken. Before and after the eclipse the photographs are taken by means of Dr. Huggins's device for mechanically shutting off the glare of the sun. The idea of Capt. Darwin's observations is to test the trustworthiness of Dr. Huggins's method. If a complete continuity appears in the series of pictures taken by what may be called the artificial and the natural methods, the confidence of solar observers in the former method will be established. The series has been duly obtained, but until the plates are closely scrutinised in England it is impossible to pronounce on the success of the test. Dr. Thorpe was in charge of an instrument prepared by Capt. Abney for the determination of the intensity of the light sent out from different parts of the corona. He has been very successful, having made no fewer than fifteen determinations.

The following is the list of grants which have been made this year by the Association:—

*A—Mathematics and Physics*

| | |
|---|---|
| Solar Radiation | £20 |
| Electrolysis | 50 |
| Ben Nevis Observatory | 75 |
| Standards of Light | 10 |
| Instructions for Tidal Observations | 15 |

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| Chepstow Meteorological Observatory | £20 |
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| *B—Chemistry* | |
| Silent Discharge of Electricity | 20 |
| Absorption Spectra | 40 |
| Translation of Foreign Records | 5 |
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| *C—Geology* | |
| Volcanic Phenomena of Vesuvius | 20 |
| Volcanic Phenomena of Japan | 50 |
| Exploration of Cae Gwyn Cave | 20 |
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| Carboniferous Flora of Halifax | 25 |
| Microscopic Structure of the Rocks of Anglesey | 10 |
| Eocene Beds, Isle of Wight | 20 |
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| Lymphatic System | 25 |
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| Plymouth Biological Station | 50 |
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| *E—Geography* | |
| Batho-Hypsographical Map | 25 |
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| *F—Economic Science and Statistics* | |
| Regulation of Wages | 10 |
| *H—Anthropology* | |
| Prehistoric Races, Greek Islands | 20 |
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## SECTION C

### GEOLOGY

Opening Address by Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.S.A., F.G.S., President of the Section

I have felt it a great honour and an especial pleasure to be asked to preside at the meeting of Section C in Birmingham. A great honour, because of the repute of my predecessors; an especial pleasure, because, as born in the Midlands, I am naturally proud of the Midland metropolis, its intellectual activity, and its commercial enterprise. Besides this, there are few towns in England where I number more friends of kindred tastes than in Birmingham. Geology especially seems to thrive in this district, and little wonder when you reckon among your residents, in addition to a host of other workers, such leaders as Crosskey, *malleus erraticorum*, Allport, who taught me how to work with the microscope, and Lapworth, to whose genius my duller mind is under constant obligation.

The addresses delivered at the annual meetings of the British Association afford a convenient opportunity for what may be termed stock-taking in some branch of science which has especially attracted the attention of the author; for a brief review of past progress; for a glance forward over the rich fields which still await exploration. We may compare ourselves to pioneers in a land as yet imperfectly known, the resources of which are only beginning to be developed. Taking our stand upon some vantage-ground at the border of the clearings, we glance forward over plains as yet untrodden, over forests as yet untracked, to consider in what directions and by what methods of investigation new lands can be won through peaceful conquest, new treasures added to the world's intellectual wealth.

I purpose, then, on the present occasion to offer a few remarks upon a branch of geological investigation which appears to me one rich in promise for future workers. The key-note of my address might be conveyed in the following sentence: "The application of microscopic analysis to discovering the physical geography of bygone ages." The ultimate aim of geological researches is obtaining answers, in the widest and fullest sense, to these two problems in the history of our globe—the evolution of life upon it, and the evolution of its physical features. In the former a host of labourers, before and since the epoch of Darwin's great book, have been employed in collecting and co-ordinating facts, and in framing hypotheses by scientific induction. In the latter the workers are fewer, but the results obtained are neither small nor unhopeful. In the past generation, men like Godwin-Austen pointed out the principles of work and gathered no small harvest, but in the present the application of the microscope to the investigation of rock-structure has facilitated research by furnishing us with an instrument of precision; this, by disclosing to us the more minute mineral composition and structural peculiarities of rocks, enables us to recognise fragments, and sometimes even to determine the source of the smaller constituents in a composite clastic rock. The microscope, in short, enables us to declare an identity where formerly only a likeness could be asserted, to augment largely in all cases the probabilities for or against a particular hypothesis, and to substitute in many a demonstration for a conjecture.

Once for all, I ask you to bear in mind that this address is mainly a recital of other men's work, so that I shall not need to interrupt its continuity by remarks as to the original observers. The subject is, indeed, one to which I have paid some attention, but I can only call myself a humble follower of such men as Godwin-Austen, "the physical geographer of bygone periods," and Sorby, who was the first to apply the microscope to similar problems, and to whom in this class of investigation we may apply the well-known saying, *Nihil tetigit quod non ornavit.*

With the deepest gratitude also I acknowlege the loan or the gift of specimens from Drs. Hicks and Callaway, from Messrs. Howard Fox, Somervail, Shipman, Gresley, Houghton, Marr, Teall, and J. A. Phillips, from Profs. Lapworth and Judd. Through their liberality I have had the opportunity of examining for myself the greater part of the materials which have already been described in the principal geological periodicals, and of adding many new slides to my own collection.

The nature of the materials of grits and sandstones has been so admirably treated by Dr. Sorby in his presidential address to the Geological Society for 1881 that I may pass briefly over this part of the subject. I will, however, add a few details in the hope of placing more clearly before you the data of the problems which are presented to us. In order to exemplify the size of the fragments with which we have to deal, I have made rough estimates of the diameters of the constituent grains in a series of quartzose rocks. Sometimes there is much variability, but very commonly the majority of the grains are tolerably uniform, both in size and shape. In a slide from the Lickey quartzite, exposed in the railway cutting at Frankley Beeches, grains, often well rolled, ranging from ·02" to ·03" are very common. In a specimen of Hartshill quartzite, they range from ·01" to ·03", but the most common size is a little under ·025". In a quartzite from west of Rushton (Wrekin) a good many grains range from ·03" to ·05." In two specimens of quartzite (white and pale grey) from near Loch Maree, the grains commonly vary a little on either side of ·02", while in a specimen of the "fucoidal quartzite" (mouth of Glen Logan) much greater variety is exhibited, a good deal of the material being about ·01" in diameter, but with many scattered grains up to ·03". The grains in a pale grey quartzite from the Bunter beds at the north side of Cannock Chase range from about ·01" to ·015", and are very uniform. In a liver-coloured quartzite from the same locality they are about as long, but narrower and sharply angular in form. These will serve as examples of what we may call an average, moderately fine grit or sandstone. It is my impression that in a very large number of ordinary sandstones most of the grains range from about one to three hundredths of an inch. In rocks, however, to which most persons would apply the epithet "rather coarse-grained," fragments of a tenth of an inch or more in diameter are common.

It is extremely difficult to give, in general terms, an estimate

of the size of the crystalline constituents of ordinary granites, and the more coarsely crystalline gneisses. But speaking of those which enter into the composition of the ground mass, I should say that the individual quartz grains do not often exceed ·03″, and are very frequently between this and ·02″. In the finer-grained granites and more distinctly banded gneisses, and their associated quartziferous schists, about ·01″ is a common size, while in the finer schists (believed by many geologists to be later in date than the aforesaid) they range from ·002″ downwards, and do not generally exceed ·001″. Feldspar crystals, where they occur, probably do not differ very materially in area from the quartz, though they are often, as might be expected, rather longer and narrower; mica crystals, cut transversely, are often longer and usually much narrower. Of other constituents, as being either rarer or more liable to change, I will not speak in detail. The individual quartz grains, in the compact and glassy varieties of the more acid igneous rocks, are about the same size as those in an ordinary granite.

Space does not permit me to enter upon the methods of distinguishing between the materials furnished by the different varieties of crystalline schists, gneisses, and igneous rocks of similar chemical composition. For the most important of these I must refer you to Dr. Sorby's address, but I may add that there are others which it would be almost impossible to describe in words, as they can only be learnt by long-continued work and varied experience. I do not pretend to say that in the case of a grit composed of fragments of about ·02″ diameter we can succeed in identifying the parent rock of each individual, but I believe we can attain to a reasonable certainty as to whether any large number of its constituents have been furnished by granitoid rocks, by banded gneisses and schists, by fine-grained schists or certain phyllites, by older grits or argillites, or by lavas and scoria. There seem to be certain minute differences between the feldspars from a granitoid rock and from a porphyritic lava, and more markedly between the quartz grains from the two rocks. The latter can generally be distinguished from the polysynthetic grains furnished by certain schists or veins, and these not seldom one from another. Obviously the larger the fragments the less, *cæteris paribus*, the difficulty in their identification. When they exceed one-tenth of an inch the risk of important error is, I believe, to a practised observer comparatively small.

Obviously, also, the shape of the grains leads to certain inferences as to the distance which they have travelled from their original source, and as to the means of transport, but into the details of this I must forbear to enter. I will merely remind you that small angular fragments of quartz are so slowly rounded when transported by running water that, if well-rounded grains appear in large numbers in a sandstone, it seems reasonable to suppose that these are, in the main, wind-drifted materials.

Thus every rock in which the constituent particles admit of recognition and of identification may be made to bear its part in the work of deciphering the past history of the globe. Where the constituents have been derived from other rocks, we obtain some clue to the nature of the earth's crust at that epoch; where the locality whence a fragment was broken can be discovered, the nature, strength, and direction of the agents of transport can be inferred. Some idea as to the structure and surface-contour of the earth in that district, and at that time, can be formed; and thus the petrologist, by patient and cautious induction, may, in process of time, build up from these scattered fragments the long-vanished features of the prehistoric earth, with a certainty hardly less than that of the palæontologist, when he bids the dry bones live, and repeoples land and sea with long-vanished races. The latter study is in vigorous maturity, the former is still in its infancy: so much wider then is the field, so much more fascinating, to many minds, is the investigation. There are many districts which are without fruit for the palæontologist—there are few indeed which, to the petrologist, do not offer some hope of reward. The field of research is so wide that not one nor few men can gather all its fruits. It needs many workers, and it is in the hope of enlisting more that I have ventured to bring the subject before you to-day.

### *Materials of the Coarser Fragmental Rocks of Great Britain* [1]

I proceed now to give a brief epitome of the constitution, so far as I know it, of our British grits, sandstones, breccias, and conglomerates. I shall exclude, as involving too many collateral issues, the Post-Pliocene beds, and dwell more on the earlier than on the later deposits, because the latter obviously may be derived from the former by denudation, so that it becomes the more difficult to conjecture the immediate source of the constituent particles. Further, in order to avoid controversy on certain questions of classification, or for brevity, I shall occasionally group together geological formations which I think separable.

It may be convenient, however, to call your attention to the localities at which, at the present day, granitoid rocks (many of which may be of igneous origin, but are of very ancient date), gneisses, and crystalline schists are exposed in Great Britain, as well as those where considerable masses of igneous rock of age not later than Mesozoic occur. The former constitute a large part of the north-western and central highlands of Scotland and of the islands off its west coast; they are exposed in Anglesey and in the west and the north of Carnarvonshire; they form the greater part of the Malvern Chain, and crop out at the Wrekin; they occur on the south coast, at the Lizard, and in the district about Start Point and Bolt Head; they rise above the sea at the Eddystone. It is probable that these last are the relics of a great mass of crystalline rock, which may have extended over the Channel Isles to Brittany; also, that we may link with the *massif* of the Scotch highlands the crystalline rocks of Western Ireland on the one hand, and of Scandinavia on the other. Among the indubitably igneous rocks we have granite, or rocks nearly allied to it, in Scotland, in the Lake district, in Leicestershire, and in Devon and Cornwall. Feldstones, old lavas, and tuffs of a more or less acid type occur in Southern Scotland, to some amount also in the Highlands, in the Lake district, and in various localities of rather limited extent in West-Central England, as well as in the south-west region just mentioned, while in Wales we have, in the northern half, distinct evidence of three great epochs of volcanic outbursts, viz. in the Bala, in the Arenig, and anterior to the Cambrian [1] grits and slates. In South Wales there were great eruptions at the last-named epoch and in Ordovician times. I have passed over sundry smaller outbreaks and all the more basic rocks as less immediately connected with my present purpose. It is, I suppose, needless to observe that a coarsely crystalline rock, whether igneous or of metamorphic origin, must be considerably older than one in which its fragments occur.

*Cambrian and later Pre-Cambrian.*—That the majority at least of the gneisses and crystalline schists in Britain are much older than the Cambrian period will now, I think, hardly be disputed by any who have studied the subject seriously and without prejudice. There are, however, later than these, numerous deposits, frequently of volcanic origin, whose relation to strata indubitably of Cambrian age is still a matter of some dispute. Therefore, in order to avoid losing time over discussions as to the precise position of certain of these deposits, or the particular bed which in some districts should be adopted as the base of the Cambrian, I will associate for my present purpose all the strata which, if not Cambrian, are somewhat older. The latter, however, exhibit only micro-mineralogical changes, and of their origin, volcanic or clastic of some kind, there can be no reasonable doubt; so that the difference in age does not appear to be enormous; that is to say, I include with the Cambrian the Pebidian of some recent authors.

The utility of microscopic research has nowhere been better exemplified than in the case of the oldest rocks of St. David's. Some authors have supposed that the base of the Cambrian series in this district has been "translated" beyond recognition, others that it has been thrust out of sight by the intrusion of granitic rock. But low down in the series, beneath the earliest beds that have as yet furnished fossils to British palæontologists, there is a well-marked and widespread conglomerate; underlying this, with apparent unconformity, comes a series of beds very different in aspect, chiefly volcanic, and beneath this a granitoid rock. The conglomerate, in places, even without microscopic examination, proves the existence, though probably at some distance, of more ancient rock, as it is full of pebbles of vein-quartz and quartzite; but in other parts it is crowded with pebbles closely resembling the feldstones in the underlying volcanic group, and in some parts becomes a regular *arkose*, made up almost wholly of quartz and feldspar,

[1] I have been obliged to exclude those of Ireland, as I have so little material from that country, and for want of space have not dealt fully with those of Scotland.

[1] I take the base of the Arenig as the commencement of the next formation, the Ordovician, which thus represents one phase of the Lower Silurian in the variable nomenclature of the Geological Survey.

closely resembling those minerals in the granitoid rock, of which also small rounded pebbles occasionally occur. One or two fragments of a quartzose mica-schist, which is not known to occur *in situ* in the district, have also been found. It is therefore evident that not only is the volcanic series somewhat, and the granitoid rock considerably, older than the conglomerate, but also that an important series of rocks, some of which were thoroughly metamorphic, was exposed in the district when the conglomerate was formed. I have very little doubt that a study of the finer-grained sedimentary Cambrian beds overlying the conglomerate will corroborate, were it needed, the conclusion which the latter justifies. Passing on to North Wales, the coarser beds in the Harlech axis, so far as they have been examined, are found to be full of fragmental quartz and feldspar, which is undoubtedly derived from a granitoid rock; some beds being made up of little else. No rock of this character, so far as I am aware, is exposed in this part of Wales, but a ridge of granitoid rock extends from the town of Carnarvon to the neighbourhood of Port Dinorwig. Through this, apparently, the great feldstone masses which occupy considerable tracts on the northern margin of the hills between Carnarvon Bay and the valley of the Ogwen have been erupted, and over this comes a series of grits, slates and conglomeratic or agglomeratic beds, overlain ultimately by the basal conglomerate of the undoubted Cambrian series. It was formerly maintained that these feldstones were only lower beds of the Cambrian metamorphosed—practically fused by some "metapeptic" process. This notion, however, was quickly dispelled by microscopic examination. The overlying conglomerate is often crowded with pebbles, identical in all important respects with the feldstone itself, which also presents many characteristics of a lava flow as opposed to an intrusive mass, and is no doubt an ancient rhyolite now devitrified. There is some difference of opinion among the geologists who have worked in this district as to the exact correlation of various gritty, conglomeratic or agglomeratic beds which succeed the feldstone, as is only natural where disturbances are many, and continuous outcrops generally few. But all agree on the existence of a series, into which volcanic materials enter largely, between the above-named basal Cambrian conglomerate and the feldstone. In this, then, and in the basal conglomerate we have again and again more or less rounded fragments of old rhyolitic lavas. We have numerous and varied *lapilli*, probably of like chemical composition. We have grits which are largely composed of quartz and feldspar, resembling that in the granitoid rock, together with fine-grained quartzose schists and bits of rhyolite, all mingled together. We have also occasionally, as in the Cambrian conglomerate near Llyn-Padarn, pebbles of the granitoid rock. Further, the basal conglomerate, as near Moel Tryfaen, is sometimes crowded with fragments of gritty argillites. Fine-grained schists, as will be noted, seem to be rare in this district, but, as such rocks occur *in situ* in the Lleyn peninsula, they will probably be discovered more abundantly when the Cambrian conglomerate is examined further in that direction.

Fine-grained micaceous, chloritic, and other schists occupy a considerable portion of Anglesey, and in the neighbourhood of Ty Croes there is an important outcrop of granitoid rock. The former were once regarded as metamorphosed Cambrian, the latter as granite which aided in the metamorphism at the end of the Ordovician period. In Anglesey the earlier Palæozoic rocks are not generally rich in fossils, so that it is sometimes difficult to settle their precise position. The oldest beds which have been thus identified have been placed in the Cambrian (Tremadoc), but some experts have doubted whether quite so low a position can be assigned to them. Hence the exact age of the oldest Palæozoic beds in this island is uncertain, as also whether the basal conglomerates near Ty Croes are of the same age as those in Carnarvonshire. This, however, is certain, that some of the Anglesey grits above the basal conglomerate are largely made up of quartz and feldspar derived from a granitoid rock. Others contain numerous fragments of very fine-grained schists, like those so abundant in the island, and the conglomerate contains pebbles sometimes full two inches in diameter, absolutely identical with the rocks in the adjacent granitoid ridge (the foliated structure distinctive of some parts of it having been even then assumed), together with various metamorphic rocks, some green schistose slaty rocks, and some reddish slates. The last two were, I doubt not, cleaved before they became fragments; probably these were derived from the hypometamorphic series, which Dr. Callaway has described, and which also contains pebbles of the granitoid rocks. Fragments of the characteristic fine-grained schists are, so far as I at present know, less common among the Anglesey grits and conglomerates than one would expect, perhaps owing to their comparative destructibility; but I have found them occasionally and suspected their presence more often. Hence there can be no doubt that older crystalline rocks have very largely contributed to the formation of at least the coarser members of the lower Palæozoics of Anglesey.

Passing now to Central England, we come to regions which may be regarded as almost the exclusive property of your local geologists. The Hollybush sandstone on the flanks of the Malvern is, no doubt, largely composed of the finer debris of the older rocks of that chain, but the Malvern hills are only an unburied fragment of a vastly larger area of crystalline Archæan rock. This is just indicated some seven miles further north in the Abberley Hills. It crops up at either end of the Wrekin, and for a little space near Rushton, but in the later fragmental rocks of the district we have abundant proofs of its existence. The central part of the Wrekin is composed of volcanic rocks, rhyolites of varied kinds, with agglomerates; these were once regarded by our highest authorities as greenstones intrusive in beds of Ordovician age, but Mr. S. Allport has taught us their true nature, and Dr. Callaway has proved their far greater antiquity. Similar rocks are to be found elsewhere in the neighbourhood of the Wrekin, and in the district farther west. We cannot affix a precise date to the volcanic outbursts of the Wrekin, but we can prove that they are not newer than the quartzite which fringes the hill, as it contains fragments of the perlitic and other glassy rocks of the apparently underlying series. This quartzite is certainly much older than the newer part of the Cambrian, and pebbles of rhyolites, resembling those of the Wrekin, occur in the indubitable Cambrian beds farther west. For instance, a grit at Haughmond Hill is quite full of fragments of volcanic rock, many of these scoria; another suggests the derivation of some of its materials from a mica-schist, while, according to Dr. Callaway, the conglomerates and grits of the Longmynds (which form the main part of the mass) are largely derived from older rocks, the former being crowded with pebbles of purple rhyolite, quartz, feldspar, mica, and occasional bits of mica-schist. A most interesting conglomerate, apparently older than the quartzite, occurs at Charlton Hill. This contains more or less rolled fragments of grits, quartzites, and argillites, looking in several cases as if they had undergone, before being broken off, the usual micro-mineralogical changes. It contains also fragments of rhyolite and many of coarse granitoid or gneissoid rocks of Malvernian type, besides numerous grains of quartz and feldspar of a like character. Finer-grained gneissoid rocks and schists, micaceous, hornblendic, or chloritic, are present in fair amount. The last bear some resemblance to the Rushton rocks, and remind me strongly of rocks which occur in the Highlands and in the Alps, apparently not in the lowest part of the Archæan series. Some also resemble the Anglesey schists. The quartzite itself is largely made up of grains of quartz which appear to me to have been derived from old granitoid rocks. Occasional grains, however, suggest by their composite structure derivation from a quartzose rock of finer texture, and, as already said, bits of the Wrekin rhyolite sometimes occur. The same is true of the Lickey quartzite, in regard to all three constituents, in which an occasional grain of microcline, very characteristic of old granitoid rocks, has been observed. The quartz grains in this and in the former rock are occasionally very much rounded. The Lickey quartzite has lately been shown by Prof. Lapworth to overlie rhyolitic rocks, and it is much older than the lowest Silurian. Not improbably it is of the same age, and was once connected with that of the Wrekin district. The Hartshill quartzite, near Nuneaton, has a similar composition, is below Cambrian, and overlies some rhyolitic rocks. Thus these insulated areas prove the existence of an old fragmental series, which is largely composed of materials derived from pre-existing and much more ancient Archæan rocks. It is difficult to assign a date to the unfossiliferous rocks forming the rugged hills of Charnwood Forest, but, as they have been affected by very ancient earth-movements, and there is nowhere any valid evidence of volcanic activity in the true Cambrians, they may be assigned with most probability to the antecedent epoch, which seems to have been one of great disturbance. Microscopic examination has shown that materials of volcanic origin enter largely into the composition of these Charnwood rocks, even the most finely grained; but besides occasional fragments of slaty rock in the breccias, for which a high antiquity cannot be asserted, we find

some pebbles of vein-quartz and two or three beds of quartzite. The grains in these appear to have been derived from old granitoid rocks, and not from the porphyritic rhyolites of the district. In one case at the Brande, they are most conspicuously rolled, and this has happened, though less uniformly, in a grit from near the ruins, Bradgate, which also contains grains of compound structure. In conclusion, I must briefly notice the so-called Torridon sandstone of North-Western Scotland, which is in many respects invaluable to the student. That it is not later than the base of the Ordovician is indisputable; that it is underlain by and derived from a mass of Archæan rocks—gneisses, more or less granitoid, with occasional schists—is universally admitted. Its coarser basement beds are crowded with fragments of the underlying gneisses and schists, and since the epoch of their formation no material change has taken place in either the one or the other. The finer beds, though other materials occasionally occur, are largely, sometimes almost exclusively, composed of grains of quartz and of feldspar identical in every respect with those in the underlying series. It may be a fact of some significance, for it agrees with what I have elsewhere noticed in very old fragmental rocks, that the feldspar appears to have been broken off from the parent rock while still undecomposed, and in many cases is even now remarkably well preserved. It would seem, therefore, as if the denudation of the granitoid rock had been accomplished without material decomposition of its feldspar, but I must not allow myself to digress into speculations on this interesting and suggestive fact. While referring to this district I may mention the quartzites, though, strictly speaking, they are Ordovician in age. These in some cases consist all but exclusively of quartz grains derived from the Archæan series, which, however, are generally smaller than those in the Torridon; it would seem as if the feldspar of the parent rock had either decomposed *in situ*, or had been broken up in consequence of the longer distance from the source of supply. This quartzite is sometimes of singular purity, containing little or no earthy material, and only rarely a flake of mica or a grain of feldspar, tourmaline, or epidote (?).

*Ordovician-Silurian.*—In regard to the earlier of these formations I am better acquainted with the volcanic than with the non-volcanic fragmental beds. Still, so far as I have seen, we find among the latter frequent indications of a supply of materials from regions of crystalline as well as of ordinary sedimentary rocks. The quartzite of the Stiper Stones (possibly earlier than the Arenig) appears to have derived most of its grains from granitoid rocks, and probably the same is true of many of the coarser beds in the Caradoc group of Shropshire and Eastern Wales. The Garth grit of Portmadoc appears to have derived much of its quartz from a like source as the Stiper Stones, but it also contains bits of a fine-grained quartzose schist and of older clastic rocks. A grit from the Borrowdale series of Chapel-le-dale contains, in addition, bits of old andesite and probably diabase, with fragments of a rather granitoid gneiss and quartzose schists. Fragments of crystalline rock, both small and large, abound in the Upper Llandovery beds at Howler's Heath, at Ankerdine Hill, in the Abberley district, on the west flank of the Malverns, and at May Hill, thus indicating that early in Silurian times far greater outcrops of crystalline rock existed than are now visible west of the Severn. Mr. W. Keeping (*Quart. Journ. Geol. Soc.* vol. xxxvii. p. 149, &c.( calls attention to the abundance of fragments of quartz, feldspar, and mica in the "greywackes" of the Aberystwith district, which give the rock sometimes quite a granitoid appearance, and adds that, in his opinion (*ibid.* p. 150), "the abundance of feldspar crystals, so general in the Silurian rocks (Upper Silurian of North Wales, South Wales, and the Lake district), points to the neighbouring presence of a vast mass of early, perhaps primæval, igneous rocks as the great source of sediment supply in Silurian times." What I have seen of the Denbigh grit of North Wales and of the Coniston beds of the Lake district confirms this conclusion. It is true that some of the material may have been supplied by Ordivician volcanic rocks, and that the quartz grains in the specimens which I have examined are not large. But we must remember that the latter can hardly have been furnished by the lavas of the Lake district; and those of North Wales, though richer in silica, do not, so far as I know, generally contain large quartzes. These, indeed, may have been derived from the denudation of Cambrian rocks, but I should doubt the sufficiency of such an explanation. In one specimen, a Denbigh grit from Pen-y-glog, near Corwen, there occurs, besides one of smaller size, a fragment about ·1" in diameter, exhibiting a micrographic arrangement of quartz and feldspar. In Cornwall, among beds which are almost certainly Ordovician or Silurian, we find similar evidence of derivation from much more ancient rocks. The conglomerates of the Meneage district contain, in addition to quartzites, greywackes, and other old sedimentary beds, abundant fragments of a moderately coarse-grained granitoid rock, and occasionally a hornblendic rock similar to the well-known Lizard schist. A series of specimens which I have examined microscopically shows, in addition to compact igneous rocks, apparently volcanic, quartz grains probably derived from granitoid rock, various fine-grained schists and schistose argillites or phyllites, quartzites, grits, and other older clastic rocks. One fragment of schist contains little eyes of feldspar, and in general structure reminds me of some in the so-called "Upper Gneiss" series of North-Western Scotland. Another, a fine-grained mica-schist or a phyllite, exhibits a cleavage transverse to the rumpled foliation.

A rich harvest probably awaits the explorer in the "greywackes" of the southern uplands of Scotland. A "Lower Silurian" conglomerate from Kingside, Peebles-shire, contains numerous fragments of igneous rocks, probably of volcanic origin, and bits of granitoid rock, with some which are either very old quartzites or perhaps vein-quartz. These have been crushed and re-cemented before being detached from the parent rock. The basement conglomerate of the Craig Head limestone group (Llandeilo-Bala) is full of rounded fragments of volcanic rocks. These, as in the last-named case, exhibit considerable variation; the majority, however, are probably andesites, and perhaps in one or two cases even basalts. A Middle Llandovery conglomerate from near Girvan is largely made up of fragments which appear to have been derived from very ancient quartzose rocks. The greywacke of rather later age from near Heriot, Edinburghshire, contains, with numerous volcanic fragments, and a little argillite, a few bits of fine-grained quartz-schist, together with grains of quartz and feldspar, suggestive of derivation from a more coarsely crystalline rock.

*Old Red Sandstone and Devonian.*—It is, I believe, indisputable that when the Old Red Sandstone of Scotland was formed a great period of mountain-making had ended and one of mountain-sculpture was far advanced. The conglomerates are often full of fragments of the crystalline rocks of the Highlands, and no doubt the sandstones derived their quartz grains from the same source. In the southern half of the country, however, as is well known, volcanic materials, more or less contemporaneous, play an important part. I have not been able to examine closely the Old Red Sandstones of England and Wales, but their frequent near resemblance to the sandstones of Scotland suggests a similar derivation. True, the materials may have been sifted from older clastic rocks, but there is nothing specially to suggest this, and the abundant pebbles of vein-quartz, which I have seen in one or two localities, seem rather more favourable to the other hypothesis. I have only examined microscopically a very few specimens of Devonian grit, all from the south side of the country. These certainly seem to have derived their materials, in part at least, from crystalline rocks, both granitoid and schists of finer grain; one specimen also apparently containing some bits of hypometamorphic rock.

*Carboniferous.*—In Scotland some of the basement beds of this series so closely resemble the Old Red Sandstone that no further description is needed, and the same remark may be made of the very few overlying sandstones which I have carefully examined. In the North of England the basement conglomerates, so far as I have seen them, are made up of earlier Palæozoic rocks, but for many of the great masses of sandstone which occur in the series a source of supply is not so easily found. Dr. Sorby, who has made a special study of the Millstone grit of South Yorkshire, tells us that it is formed of grains of quartz and feldspar, apparently derived from a granite, and contains pebbles, sometimes an inch or so in diameter, of vein-quartz, of hard grits, of an almost black quartz-rock or quartz-schist, and of a non-micaceous granite. He also notes one fragment of a greenstone, and another either of a fine-grained mica-schist or of a clay-slate. The granite, he states, more resembled those of Scandinavia than any one now visible in Britain, and the bedding indicated a supply of materials from the north-east. In the Millstone grit near Sheffield he says that the grains appear to be but little worn, as if they had not been drifted from far. A few also appear to have been derived from schists. From what I have myself seen, I anticipate that Dr. Sorby's conclusions may be extended to most of the other coarser Carboniferous clastic beds of Northern England, except that, perhaps, as was inferred by Prof. Hull,

another important, if not the principal, source of supply must be sought on the north-west. The materials of the basement conglomerates and grits in North Wales appear to be either Palæozoic rock or vein-quartz and an impure jasper; but a microscopic study of carefully selected specimens, especially from Anglesey, might produce interesting results. In Central England, as the Old Red Sandstone is commonly absent, and, if present, must have been speedily buried, we should naturally look further afield for the materials of the Coal-Measure sandstones and Millstone grit, where it occurs. But probably we shall be right in including this, as indicated by Prof. Hull, with the northern district. He also points out that in the south-western part of England and in South Wales there is good evidence that the materials have been brought by currents from the west. I have only examined one specimen from this region, but it has proved very interesting. It is from a Carboniferous grit near Clevedon, in Somersetshire. About one-third of the rock consists of quartz grains which I should suppose derived from schists or gneisses of moderate coarseness; quite another third of fragments of a very fine-grained micaceous schist, about ·03″ long. It is possible that these may be phyllites, but I think it far more probable that they are true schists. They are very like some of the more minutely crystalline schists of Anglesey, and it is evident in some cases that the rock had been corrugated subsequent to foliation. This grit also contains a few bits of feldspar and flakes of mica. I must not forget to mention some curious boulders which have been discovered occasionally in actual coal-seams. Through the kindness of Mr. Radcliffe I have been able to examine some specimens found at Dukinfield Colliery. They are hard quartzose grits and quartzites, bearing a general resemblance to sundry of the earlier Palæozoic rocks. One of the latter is as compact and clean-looking as the well-known quartzite of the North-Western Highlands. Besides quartz, and perhaps a little feldspar, it contains a small quantity of iron-oxide (?), two or three flakes of white mica, a grain or two of tourmaline, and of a mineral resembling an impure epidote. A similar quartzite has been found by Mr. W. S. Gresley in a coal-seam in Leicestershire, and I have described another from the "thirteenth coal" at the Cannock Chase Colliery. In each of these quartzites the two minerals last named may also be detected.

Before quitting the Carboniferous series I must call attention to some interesting grits which during the last few years have been struck in deep borings. In the London district a red sandstone, in some places conglomeratic, has been found underlying sundry members of the Mesozoic series. Some have thought this of Triassic age, but inasmuch as it is very doubtful, as we shall presently see, whether the coarser beds of the Triassic formations extended so far to the east, and the dip of the red beds in the well at Richmond agrees better with that of the Palæozoic rocks in other parts of the buried ridge, I think these sandstones more probably older than any part of the Mesozoic series, perhaps not very far away from the base of the Carboniferous. In the boring at Gayton, in Northamptonshire, Lower Carboniferous rocks were succeeded by reddish grits and sandstones. The finer beds much resembled the ordinary Old Red Sandstone, and, like it, suggested a derivation from fairly coarse-grained crystalline rocks. But of the origin of one rock, a quartz-feldspar grit, there can be little doubt. I may briefly describe it as very like the Torridon sandstone of Scotland, except that the cement is calcareous. I do not, indeed, claim for it a like antiquity, for I think it far more probably about the age of the lowest part of the Carboniferous series; but it, too, must have been derived from granitoid rocks. While some of the grains are fairly well rounded, others, especially of feldspar, as in the Millstone grit of South Yorkshire, do not seem to have travelled very far.

*Permian.*—The sandstones of the northern area belonging to this formation do not, as far as I have been able to ascertain, afford us much information. Quartz grains, of course, abound, but as they are rather small, it is not possible to be sure whether they have been primarily derived from a granitoid rock or a schist. The former, however, appears to me the more probable source. They also contain fragments of feldspar still recognisable, flakes of mica, and possibly a little schorl. The frequent occurrence of crystalline quartz as a secondary formation in these sandstones is a point of much interest, but has no relation to my present inquiry. The breccias near Appleby, Kirkby Stephen, &c., which I have not seen, indicate that at this time not distant masses of Carboniferous limestone, and of earlier Palæozoic rocks, were undergoing denudation; but it appears to me improbable that the finer materials of the sandstones were furnished by any rocks in the vicinity.

The Permians of the central area offer a rich field for future work. For the materials of the sandy beds I should conjecture a distant source, but for the pebbles in the conglomerates, and the fragments in the breccias, we need not travel very far afield. The Lower Carboniferous Measures contributed limestone and chert, the former being especially abundant in the conglomerates, but the "vein-quartz, jasper, slates, and hornstone," mentioned by some observers, indicate that yet earlier rocks furnished their contingent, while of the igneous materials I will speak directly. I shall pass very briefly over the breccias, so well displayed, for instance, on the Clent and Lickey hills, at no great distance from this town, because I trust we shall have presented to us, in the course of this meeting, a sample of the rich harvest which is awaiting explorers. Earlier investigators looked towards Wales for the origin of these fragments; we shall, I believe, learn that the majority are more probably derived from rocks, which, though now almost hidden from view, exist at no great distance. Some of the more compact traps may have come from the old rhyolites, which, by the labours of your geologists, have been detected *in situ* beneath the Lickey quartzite, while we may venture to refer the "red syenite" and "red granite" to outcrops of crystalline rocks of Malvernian age. These breccias have been regarded as proving the existence of glaciers in the Lower Permian age. It is, of course, possible that floating ice has been among the agents of transport, but after carefully examining the specimens in the museum of the Geological Survey on which glacial striæ are asserted to occur, I am of opinion that the marks are due to subsequent earth-movements. On only one specimen did I recognise glacial striation, and this pebble is so different from the rest that I think it must have come from drift, and not from the Permian beds.

No less interesting are the Permian breccias of Leicestershire. These have attracted the attention of an indefatigable local geologist, Mr. W. S. Gresley, and to his kindness I am indebted for the opportunity of examining both rock specimens and slices. As might be expected, fragments, which I have no hesitation in referring to the Charnwood series, are not wanting, though hitherto they have not occurred in any abundance; but perhaps the most interesting member is a tolerably hard conglomerate, containing rather abundantly pebbles of a speckled grit and of a compact "trap." Microscopic examination of this conglomerate, which varies from a fairly coarse puddingstone to a grit, shows that the above-named speckled grit is composed of small and rather angular fragments of quartz, associated with grains of brownish and greenish material, which may be in some cases decomposed bits of a rather basic lava, in others possibly a glauconite of uncertain origin. But the "trap" pebbles are yet more interesting. These are the more numerous, and are commonly well rolled. They probably belong, roughly speaking, to one species, but exhibit many varieties. In a single slide I have seen at least six, perfectly distinct. Some are indubitably scoriaceous, others full of microliths of a plagioclastic feldspar, others almost black with opacite, others mottled brown devitrified glasses, more or less fluidal in structure. Probably they belong to the andesite group, with a silica percentage not very far away from sixty. In none have I observed any signs of crushing or cleavage, so that I cannot refer them to the Charnwood series, but conjecture that they are relics of volcanoes later in age than the great earth movements which affected that series, though I cannot connect them with the more basic post-Carboniferous outbreaks of which we have indications at Whitwick and elsewhere. Quartz grains also occur, and some of these exhibit a rather peculiar "network" of cracks which is characteristic of this mineral in the rocks of Peldar Tor, Sharpley, &c., and one such grain is attached to a fragment of minutely devitrified rock. Hence, as shown by larger fragments, the Charnwood series has contributed to the materials of this conglomerate, but the more abundant appear to have been derived from volcanic vents, the locality of which is at present undiscovered.[1]

*Trias.*—The Bunter beds and the lower part of the Keuper consist of more or less coarse materials, while in the remainder of the latter such deposits are rare and local. Hence it is evident that after the deposition of the Keuper sandstones a very different set of physical conditions prevail. The lower series consists of sandstones and conglomerates; these beds occur in

[1] I pass by the interesting pebbles of hæmatite, which have received special attention from Mr. Gresley.

considerable force on the eastern side of the Pennine Chain, have a great development in Lancashire and Cheshire, and thin away towards the south-east, almost disappearing in eastern Leicestershire and in Warwickshire. As the Trias is followed southwards, along the valley of the Severn, the Bunter in like way dies out, while the Keuper marls may be traced on into Somersetshire and Devon. In that region also there is a grand development of the lower and coarser members. As might be expected, there are considerable differences between the lower Triassic deposits of the northern and southern areas, so that it will be convenient to speak of them separately. The northern group, as is well known, is separable in the Midland and north-western district into the Lower Bunter sandstone, the Pebble-beds, and the Upper Bunter sandstone, over which come, more or less unconformably, the Keuper sandstones. Pebbles are either absent from, or very rare in, every part of the Bunter except the pebble-bed, and are generally small and scarce in the Keuper sandstones, except in the basement breccias. It will be convenient to make a few remarks on them before dealing with the associated sands and sandstones. The pebbles in the Bunter conglomerate are most abundant, and generally attain the largest size in the Midland district. Towards the north-west, though the conglomerate attains a thickness of more than 500 feet, pebbles are rarer and smaller, and this, I believe, is also the case in Yorkshire, though the thickness of the deposit is not so great. I can, however, answer for the occurrence of pebbles of fair size and in considerable abundance for some distance to the north of Retford. In the Midland district they are very frequently from about 2" to 4" in diameter, though smaller are intermingled and occasionally some of large size; these attain in certain localities to a diameter of 6", or even a little more. The majority, as far as I know, are well rounded. In this district many different kinds of rock are found in the conglomerate; the most abundant are quartzose—vein-quartz, quartzites, and hard grits or sandstones. Besides these we find chert and limestone from the Carboniferous series, various fossiliferous rocks of Silurian, Ordovician, and possibly Cambrian age, with mudstones and argillites, more or less flinty, of uncertain date. Feldstones, using the term in a wide sense, are not rare, and granites or granitoid rocks sometimes occur. These, however, together with the scarce fragments of gneiss and schist, are usually very decomposed. A hard quartz-feldspar grit, sometimes very like a binary granite, may be found, and I have noticed a peculiar black quartzose rock of rather schistose structure. As the lithology of the Bunter conglomerate has already attracted the notice of more than one author, I shall restrict myself to a brief mention of its more salient features. The most abundant rock is a quartzite, frequently so compact as to give a rather lustrous sub-conchoidal fracture, in which the individual grains can be with difficulty distinguished. In colour it varies mostly from white to some tint of grey, but is occasionally "liver-coloured." Rather obscurely marked annelid-tubes are the only organic indications which I have observed in these quartzites, and these are very rare. Under the microscope the rock consists chiefly of quartz fragments, of various forms in different specimens, with an occasional fragment of feldspar (sometimes, I think, silicified), a flake of white mica, a grain of tourmaline, and of an impure epidote (?). As a rule it is easy to distinguish this quartzite from the other indurated arenaceous rocks which occur in the conglomerate, especially from those containing fossils.

The above-described quartzites differ in appearance both macroscopically and microscopically from those of Hartshill, the Lickey, and the Wrekin district, but they closely resemble the most compact variety, which I have already described as occurring in boulders in coal. They have also an extraordinary likeness to quartzite pebbles in Old Red Sandstone and Lower Carboniferous conglomerates of Southern Scotland and to the quartzites of the Northern and Western Highlands, already described, a liver-coloured variety of which, as I have been informed, occurs in the island of Jura. These quartzite pebbles, to my knowledge, may be traced into Lancashire on the one side of the Pennine Chain and to beyond Retford on the other. The quartz-feldspar grit consists mainly of quartz and feldspar, obviously the debris of granitoid rock. I have found it at various localities on the northern margin of Cannock Chase, and have received specimens from the Bunter beds near the Lickey and near Nottingham. The rock, macroscopically and microscopically, presents an extraordinary resemblance to the Torridon sandstone of North-West Scotland, and differs from every other rock which I have seen *in situ* in any other part of Britain. The nearest approach to it is the quartz-feldspar grit, already mentioned as having been struck in the Gayton boring, Northamptonshire, but this has a calcareous cement. The feldstones vary from micro-crystalline to glassy rocks more or less devitrified, some being slightly scoriaceous. They may be classified lithologically as quartz-felsites, rhyolites (more or less devitrified), quartz-prophyrites, porphyrites, and old andesites. Some specimens contain a considerable amount of tourmaline, and I have seen this mineral in the vein-quartz pebbles. It also occurs rather abundantly in a very hard, black quartzose grit. I have received varieties of feldstone, which I have found on Cannock Chase, from the Bunter beds of the Lickey and from Nottingham. In Staffordshire pebbles of granitoid rock, gneiss, and schist are not only rare, but also generally too rotten to admit of examination; but I found a few months since, in the conglomerate at Style Cop, near Rugeley, two pebbles of a whitish gneiss, which appeared to me to indicate a secondary cleavage-foliation, such as may be observed in many parts of the Scotch highlands. The black quartz-schist already mentioned exhibits a peculiar "squeezed-out" structure, which ordinarily indicates that the rock has undergone great pressure.

The sandy matrix and associated sandstones of the conglomerate beds, together with those of the Upper and Lower Bunter, and of the Lower Keuper, consist mainly of quartz grains, most of which appear to have been derived originally from granitoid rocks. They are often more or less angular, but at certain horizons, as described by Dr. Sorby, Mr. Phillips, Mr. G. H. Morton,[1] and others, well-rounded grains are so abundant as to suggest an exposure to the action of the wind. They are often stained red with iron peroxide, and mixed with more or less earthy matter. In Cheshire and Lancashire recognisable grains of feldspar have been noticed by Mr. Morton and others, and probably this mineral is, in most cases, the source of the argillaceous constituents which are often intermingled with the quartz grains. Flakes also of white mica are sometimes rather common. So far as I have been able to judge, distinct grains of rolled feldspar are commoner in the north-western district than in Staffordshire, where, however, mica-flakes are sometimes rather abundant.

The Keuper sandstone seems to me to differ from the above only in the general absence of the red colour, and in a more even bedding, especially towards the upper part (the waterstones), where they are interbedded with the marls. The appearance of these last suggests that the currents were gradually losing strength, and only capable of transporting the finer feldspathic detritus with occasional tiny plates of mica.

The lithology of the lower part of the Trias in the southern area is as yet imperfectly worked out, and a rich harvest awaits the student. My own knowledge of it is but superficial, so that I must pass it by with a brief notice. The great beds of breccia, so finely exposed on the South Devon coast, are crowded with fragments, sometimes of large size; these have clearly been derived from the older rocks which are still in part exposed to the west and south-west, and probably had once a much greater extension in the latter direction. Fragments of Devonian limestone, grits, and slate, together probably with other Palæozoic rocks, earlier and later, are mingled with granites, resembling those of Cornwall and Devon, and many varieties of more compact igneous rock. The fossiliferous quartzite pebbles which occur mingled with others in the Trias at Budleigh Salterton, have been discussed by the late Dr. Davidson in an exhaustive memoir ("British Fossil Brachiopoda," *Mem. Palæont. Soc.* vol. iv. p. 317). He refers the majority of the fossils obtained from them to the Lower Devonian age, but a few are Caradoc, and four occur in France in beds which are either Llandeilo or perhaps a little older. As the first two formations are represented, lithologically and palæontologically, on the opposite side of the Channel in France, and the third is at present only known to occur in the *Grès Armoricain* of that country, he thinks it probable that these pebbles have been derived from rocks which are now concealed beneath the waters of the Channel. It may then, I think, be taken for granted that land to the west and south-west has supplied the materials of the Lower Trias of the southern district of England, and I may add that there is every reason to believe that outliers of the formation itself still exist beneath the sea.

The so-called dolomitic conglomerates, which occur chiefly in

[1] In an excellent paper published in the *Proceedings* of the Liverpool Geological Society, vol. v. p. 52.

Somersetshire, have been so fully worked out by Mr. Etheridge and Mr. Ussher as to require but a passing notice. It is evident that they differ somewhat in date, though probably all may be referred to the age of the Keuper, and that they are local breccias or conglomerates formed around the margin of islands or on a continental coast-line during a gradual subsidence and in comparatively quiet waters.

*Jurassic.*—Coarse detrital material is not very common in the Jurassic series. The limited Rhætic beds indicate a transition from the peculiar physical conditions of the Keuper to the marine conditions of the Lias, and the sediment in them was probably derived from the same source as the Keuper marls. Great clay beds also occur, as is well known, throughout the Jurassic series; and the sandstones, so far as I have been able to examine them, do not enable me to offer any suggestions as to their origin. Probably some of the grains were originally derived from granitoid rocks, but they may have been directly obtained from other sandstones. A grit, however, in the estuarine series of the lower oolites of Yorkshire (Mr. Phillips's collection) looks as if it might have been partly derived from a schist, but as this is the only rock from the northern area which I have had the opportunity of minutely examining, it would be imprudent to speculate.

*Neocomian-Cretaceous.*—I have examined very few specimens from the fresh-water Neocomians of the south of England, but, so far as I have seen, I should think it probable that the quartz had been derived from old crystalline rocks, though perhaps not immediately. The same remark applies to the sands of the upper and marine series, which, in one instance at least, exhibit exceptionally rounded contours.[1] Among these, however, conglomeratic beds occur which have already attracted some attention. It is obvious that no small part of the materials, as at Farringdon, Potton, and Upware, has been derived from fossiliferous secondary rocks of earlier date. There are also pebbles of vein-quartz and quartzite which, however, may have been obtained by the denudation of Triassic rocks. The "Lydian stone," which is abundant in angular or subangular fragments at Potton and Upware, is for the most part chert from the Carboniferous Limestone, or in some cases from Jurassic rocks, but a few specimens may be flinty argillites, and thus of greater antiquity. One or two pebbles of older Palæozoic rock have been found, and a hard quartz grit has occurred, containing among its grains minute acicular crystals, probably of tourmaline. Potton has furnished one or two pebbles which appear to be a devitrified pitchstone, and a large pebble of porphyritic quartz-felsite has been sent to me by Mr. Willet from Henfield (Sussex). These conglomerates, together with others in the Upper Neocomian of England, have been so fully described by Mr. Walter Keeping (*Geol. Mag.* Dec. 2, vol. vii. p. 414), that I need not enter into further details, though I am well aware that the subject is by no means exhausted.

For a like reason I may pass briefly over the remarkable erratics found in the Cambridge greensand (Sollas and Jukes-Browne, *Q. J. G. S.* vol. xxix. p. 11). They occasionally slightly exceed a cubic foot in volume, but are generally smaller. Among them are diverse sandstones and grits, probably Palæozoic, granite, gneiss, various schists, quartzites, and slates, besides greenstone, a very coarse gabbro or hypersthenite, and a compact feldstone. I think it highly probable that many of these erratics came from the north, in some cases almost certainly from Scotland, and were transported by ice, though I am not satisfied that any exhibit true glacial striæ. In the south of England a boulder of old quartzose rock, perhaps a piece of a coarse quartz-vein, crushed and re-cemented, has been found by Mr. J. S. Gardner in the gault, and in the chalk we have the well-known cases of the granitic rock and other boulders at Penley, near Croydon, and of coal (Wealden or Jurassic) in Kent (Godwin-Austen, *Q. J. G. S.* vol. xvi. p. 327). Mr. Godwin-Austen describes other instances of pebbles in chalk, and I have received two or three small specimens from Mr. W. Hill, from about the horizon of the Melbourne rock, which, however, have not yet thrown any light on the subject.

*Eocene.*—Previous writers have called attention to the fact that the sand of the Thanet, Oldhaven, and Bagshot beds is mainly composed of quartz. This is abundantly confirmed by my own observations. So far as I have seen, in all these the grains are not, as a rule, conspicuously rounded. It can hardly be doubted that older sandstones or granitoid rocks lying to the west have furnished the materials of the Bagshot series, which still has so wide an extension in that direction; their lithological similarity would lead us to took towards the same quarter for the materials of the more limited Oldhaven and Thanet beds. The well-rolled flint pebbles in the Oldhaven series, and in occasional layers in the Bagshot, suggest the proximity of a shore-line of Upper Cretaceous rocks.

I have had no opportunity of adding to what has been written on the lithology of the limited Pliocene deposits in England, and, as stated at the outset, have excluded from the scope of this address all beds of later date, which have been so ably discussed by Mr. Mackintosh, Dr. Crosskey, and many other geologists.

### *Principles of Interpretation*

In attempting to interpret the facts which I have enumerated we must bear in mind the following principles:—

(1) Pebbles indicate the action either of waves of the sea,[1] or of strong currents, marine or fluviatile.

(2) The zone in the sea over which the manufacture of pebbles can be carried on is generally a very narrow one. It extends from the high-tide line to the depth usually of a few feet below low-water mark. It is estimated that as a rule there is no disturbance of shingle at a greater depth than twenty feet below the latter. It is therefore probable that a thick and very widely extended pebble bed is not the result of wave action.

(3) The movement of the deeper waters of the sea as a rule is so slight that only the very finest sediment can be affected by it. Now and then great currents like the Gulf Stream, or more locally "races," may have sufficient power to transfer pebbles and sand, but instances of this will be exceptional, and confined to rather shallow water. The larger coast currents, however, may transport mud to considerable distances, but in directions parallel with the main trend of the shores.

(4) Except where very large rivers discharge their water into the ocean, or in some special case of (3), sediment is deposited comparatively near the shores of continents. Even in the case of very large rivers only the finer sediment is carried far from land. The *Challenger* soundings have shown that 150 miles is about the maximum distance from land within which any important quantity of detrital materials is deposited.[2] As a rule (so far as I can ascertain), the coarser sediments are generally deposited within a few miles of the coast. Hence this is fringed by a zone of sediment, which, after passing a maximum thickness within a short distance from the shore, gradually thins away. I doubt whether this detrital fringe is often more than seventy or eighty miles wide; probably the coarser sands do not usually extend for so much as a quarter of this distance. The inertia of the mass of the ocean water quickly arrests the flow of even the mightiest river or reduces it to a mere superficial current. Hence the great ocean basins are regions where rock-building is carried on slowly and chiefly by organic agency. Their borders bear the burden, and the load taken off the continent is laid down on the bed of the adjacent sea.

(5) Thus rain and rivers are generally more important agents of denudation and transportation than the sea, because unless the land be rising or sinking the zone over which the latter can operate is limited both vertically and horizontally.

(6) The coarser materials of rock are capable of being transported by streams to considerable distances without serious diminution of volume. Prof. Daubrée has proved experimentally that a stream flowing at the rate of about two miles per hour would roll angular fragments of quartz or hard granite into perfectly smooth pebbles after a transit of 25 kilometres ($15\frac{3}{4}$ miles). During this process the fragments lost about four-tenths of their weight. Further transport reduced the volume of the pebbles very slowly. The loss afterwards varied from 1/1000 to 4/1000 per kilometre. To reduce a pebble of 2 inches diameter to 1 inch diameter—that is, to diminish its volume by seven-eighths—would require a journey of from about 219 to 875 kilometres (approximately from 137 to 548 miles). This approximation, rough as it is, becomes still less exact as the pebbles decrease in size; the rate of diminution in volume (*cæteris paribus*) bearing a relation to the area of the surface. Thus the smaller the pebble the further it will travel without material diminution of size. Sand grains are even rounded with extreme

[1] Prof. Rupert Jones has called attention to sand-worn pebbles in the Upper Tunbridge Wells sandstone of the Weald (*Geol. Mag.* Dec. 2, vol. v. p. 287).

[1] The waves of lakes also have some rounding effect, but this—except in the case of very large lakes, such as Lake Superior—is not important; and such cases are, of course, not of common occurrence.

[2] I except floating pumice, cosmic dust, &c., as comparatively unimportant.

slowness. According to the same author a quartz grain 1/50 inch in diameter requires to be transported by water action some 3000 miles before losing its angles. On this account the presence in a sandstone of numerous well-rounded grains is taken to indicate the action of wind, for, as is well known, blown sands are much more quickly rounded.[1]

(7) Thus deposits of gravel and coarse sand, of considerable vertical thickness and great extension, are more likely to indicate the immediate action of a river than of a marine current. If limited in extent they may have been formed at the embouchure of a river into a lake or sea. If, however, they can be traced for long distances, they are more probably in the main sub-aërial deposits from rivers.

The following examples may convey some idea of the kind of river which would be required to transport the more important deposits of grits and stones mentioned in the first section of this address:—

The old river-gravels of the Sierra Nevada are "in some places 300 or 400 feet thick and almost homogeneous from top to bottom," sometimes they even obtain a thickness of 600 feet. Mr. Whitney is of opinion that the fall in these old river channels was probably from 100 to 130 feet per mile. Apparently, however, we need not invoke so large a fall as this. The total fall of the Danube is 3600 feet, and its length 1750 miles. From Passau to Vienna the fall is 1 in 2200, from Vienna to Old Moldava 1 in 10,000. Yet the velocity of the current from Vienna to Basias (fifteen miles above Old Moldava) is "from two to three knots an hour," depending on the amount of water. This would suffice to transport pebbles of the average size of the English Bunter. Below the Iron Gates the fall is still less rapid, but sand is carried down for a very considerable distance. If then the rivers of the old continental land resembled the larger streams of Europe, they would suffice for the transport of the materials with which we have dealt, especially if aided by coast currents after the debris had reached the sea.

(8) If boulders occur in a matrix consisting of fine mud, or mainly of organic material, they must (unless they are volcanic bombs) have floated thither either attached to large seaweeds or entangled in the roots of trees, or supported by ice. If they are rather numerous and a foot or more in diameter, in a marine deposit, the last is the most probable mode of transport. A cubic yard of ice will more than suffice to float a cubic foot of average rock.

### *Conclusion*

The facts already mentioned, regarded in the light of the above principles, justify, in my opinion, the following inferences as to the past physical geography of our country. At the commencement of the Cambrian period great masses of Archæan rock, granites, gneisses, and schists, must have existed, not only on the western side of Britain, but also over a considerable tract of land now covered by the sea. Detritus from this continent became an important constituent in the Cambrian rocks, and in many cases, as at St. David's, in Anglesey, Carnarvonshire, &c., the shore-line must have been very near at hand. With the Cambrian period commences a long-continued subsidence, so that its basement beds at different places are very probably not all of quite the same age. The land surface was from the first irregular, and it is very probable that waves of the sea were fretting away some parts, while rain and river, heat and cold, were still sculpturing others. But among the materials of the ancient land were not only granitoid rocks, gneisses, and schists, but also newer strata more distinctly of clastic origin, memorials of past denudation—quartzites and grits, phyllites and slates, not to mention others—and these, by their intimate structure, sometimes indicate that great earth-movements must have already occurred.[2] In many localities, perhaps as a result of these disturbances, there occurred, towards the conclusion of the Archæan period, great volcanic outbursts—by which, no doubt, numerous cones were built up, and many of the materials of the so-called Pebidian group were supplied. It is, I think, at present hardly safe to attempt to trace the exact land boundaries of the Cambrian ocean, but the enormous masses of Archæan material which are entombed in the earlier Palæozoic strata of Wales and of North-West Scotland can, I think, only be explained by the proximity of a great continental land—an extension of the present Scandinavian peninsula—which not improbably had a general slope towards the south-east, the main watershed of which may have lain some distance to the west of the Outer Hebrides.[1] But even over the more central parts of Britain there cannot have been deep or open ocean. We are constantly coming upon the traces of pre-Cambrian and early Cambrian land; some of our Mid-England Archæan masses, like the Malverns, appear to have risen above the water, and to have undergone denudation after the great earth-movements which ushered in the Silurian period. Prior to this, after a time of repose in the Cambrian, at more than one epoch, and in more than one place, there were great volcanic outbursts, which appear to have studded the sea with volcanic islands, and to have added to the heterogeneous materials from which the sediments were now formed. It is evident that in Silurian times the coast-line had extended southward and eastward. The coarse deposits of this age, in Wales, the Lake district, and Southern Scotland, compared with the finer mudstones and limestones of the Welsh border and of England, seem fully to bear out this assumption, which is in accordance with a well-known law of mountain-making. The Old Red Sandstone of Scotland and of Wales indicates a yet further continental extension towards the south east. A great epoch of mountain-making in the Scotch highlands, which had perhaps been going on at intervals from the beginning to the end of the Silurian period, had now come to an end; the southern uplands had risen up, like a Jura to the Alps. But probably their elevation did not terminate the earth-movements, for the post-Silurian cleavage of the Lake district, and the absence of Old Red Sandstone both here and in Central England indicate that the Palæozoic land mass continued to extend on its south-eastern flank. The Devonian period introduces us in the greater part of Great Britain to an epoch of limited and exceptional deposits, and of widely prevalent terrestrial conditions. It seems almost certain that the Old Red Sandstones of Scotland and Wales are of fresh-water origin—the deltas of rivers, formed either in lakes or possibly in part as sub-aërial deposits. Streams of considerable volume and of some strength are indicated by the materials. In one case, the Old Red Sandstone of North-East Scotland, we may perhaps discern in the Great Glen some indication of the old river course. It is easy to ascertain the source of the materials of the Scottish Old Red Sandstones. They are as obviously the detritus of the Highland mountains—then probably a far grander and loftier chain—as the nagelflue and the molasse of Switzerland are of the Alps.

At this time marine conditions prevailed in the south of England. The sea appears to have deepened towards the south, but I suspect that a region of crystalline rock still existed at no great distance in that direction and in the west. Probably the Brito-Scandinavian peninsula curved round to the east so as to include some part of Brittany.[2] Another great epoch of subsidence now commenced, commemorated by the formation of the Carboniferous limestone. At this I need hardly glance, as it has been so fully discussed by Prof. Hull and other writers. The land sank both in the north and in the south of England. There was deep sea over Derbyshire and Southern Wales, but the ground beneath our feet probably remained above water, forming either a continental promontory or a large island.

There were other well-known interruptions to the sea, which also overflowed a considerable part of Ireland and districts far to the east of England. The Scotch highlands, however, probably remained above water, for, as is well known, the Carboniferous limestone of Central Scotland overlies a fresh-water formation, and is itself not wholly marine, since it contains coal, and like conditions prevailed in Northumberland.

Gradually, however, the sea shallowed, and terrestrial conditions returned. In the later part of the Carboniferous series we have clear indications of two, or perhaps three, important currents, almost certainly those of rivers, bringing materials, in the southern district from the west; in the northern, from the north-west and probably the north-east. These materials may have been in part derived from older Palæozoic rocks, but the facts when fairly considered seem to indicate that there was also an extensive denudation of crystalline and not improbably Archæan rocks, unless we suppose that great areas of eruptive Palæozoic granite have now disappeared beneath the waters. At any rate, we may perhaps regard the open water between Ireland

[1] See on the subject of this paragraph Daubrée, "Géol. Expériment.," vol. i. sec. 2. ch. i., and J. A. Phillips, *Q. J. G. S.*, vol. xxxvii. p. 21, &c.

[2] It is evident, for instance, that the north-west strike, and other effects of folding, had been produced in the Hebridean series of North-West Scotland before the Torridon sandstone was deposited.

[1] Possibly the comparatively rapid deepening of the Atlantic beyond the 100-fathom line may have some relation to the western outline of this primæval Atlantis.

[2] Compare, as an illustration, the curving round of the Alpine chain on the western side of Italy.

and Scotland on the one hand, and to the east of the latter country on the other, as significant of a denudation earlier than that of the sea which has in later times divided the British Isles. Another epoch of earth-movements closed—as was to be expected—the Carboniferous subsidence and deposition. We trace one line of flexures and of intense compression along a broad zone, including the south of England, from Germany to Ireland; another less intense over the northern part of our country; the axes of the former flexure striking a little north of west, of the latter about west-south-west. The one appears to me to indicate a thrust from a great mass of hard, more or less crystalline rock in the south, which probably led to the formation of a mountain-chain extending from North-Central Europe over the Channel to the southern margin of England. The latter may be explained by the presence of the above-named north-western continent.

In the Permian time terrestrial conditions probably prevailed over a large part of Britain. It is extremely difficult to ascertain the exact circumstances under which the Permian beds of Central England were deposited, but I should think they imply a return to physical conditions not unlike those of the Old Red Sandstone, though perhaps the marine fossils which have been found in Warwickshire may indicate that the water there had some imperfect connection with the sea. I must not discuss the vexed question of the age of the Pennine Chain, but must content myself with expressing my opinion that, at most, it can only, as yet, have very partially interrupted the continuity of the water in Northern England. The beds there appear to indicate a supply of materials from the north and north-west, as if the old rivers had not been wholly diverted by the great earth-movements which closed the Carboniferous period. Sir A. Ramsay's view, that the water in which the dolomitic limestone was deposited was more or less cut off from the open sea, seems to me by no means improbable; in any case, it is a rather exceptional formation, and over the greater part of Britain, probably, land sculpture continued, and deposition was on the whole local.

With the Trias a new era commences; physical features had been now produced, which in all probability endured through a considerable part of Mesozoic times. The facts which I have laid before you, regarded in the light of the general principles indicated above, compel us to look away from the immediate vicinity for the bulk of the materials, coarse and fine, of which the northern Trias is composed, though neighbouring hills may have furnished occasional contributions, especially to the earlier deposits. The analogy of the Old Red Sandstone, the Calciferous Sandstone of Scotland, and the Nagelflue and Molasse of Switzerland, together with other peculiarities too well known to need repetition, make it in the highest degree probable that the Bunter beds were not deposited in the ocean.[1] Hence they must be either deltas formed in an inland sea or in a lake, or true fluviatile deposits. Neither lake nor inland sea appears likely to have been sufficiently large to admit of waves or currents capable of either rounding the pebbles or transporting the materials. We are therefore compelled to fall back upon the action of rivers. The sandy beds of the Bunter indicate a stream flowing from one-third to half a mile an hour, the pebbles one from two to three miles; that is to say, the Upper and Lower Bunter sandstones would require the former rate of movement, the Pebble Beds the latter. Now, we must remember that, in the West-Central district, the Lower Trias consists of three wedge-like masses, about a hundred miles in length, of which the coarser is probably the more extensive. The comparative uniformity of the deposits in each case indicates a uniformity of flow, and suggests either a large and broad stream, not liable to much variation, or one which, when flooded, quickly made a channel of its valley, and deposited mainly at such season. I have the greatest difficulty in understanding how a current of the requisite velocity could be maintained by the water of a river or rivers flowing into a lake or an inland sea, or in explaining the tripartite arrangement of the beds on the hypothesis that a basin was gradually filled up from the northward by a stream which, like the Rhone at the upper end of the Lake of Geneva, gradually advanced its delta by flowing over the materials which it had previously deposited in the basin. Hence I believe that we must regard the Bunter beds as subaërial deltas, analogous to the conglomerates in the Siwalik deposits of India,[2] and to the sandstone and nagelflue on the outer zone of the Alps, deposits in all respects very similar to the English Bunter. We may suppose, then, that rivers emerging on each side of the Pennine Chain from a mountain land first formed the Lower Bunter sandstones, then, owing to increasing upheaval in the mountain district, and corresponding depression in the lowlands, flowed more swiftly so as to cover this deposit with the Pebble Bed, and lastly, as its former conditions returned, laid upon this the Upper sandstones. I have spoken, for the sake of clearness, as if these were perfectly distinct formations, but it would by no means follow that some part of the finer beds to the south-east might not be contemporaneous with a portion of the coarser beds to the north-west, as the velocity first increased, and then diminished. As I have already said, the materials of the pebbles and of the sand make it impossible to refer the main constituents to local sources. Many of the rocks do not exist in the Midland; there is no reason to suppose that at that time there were in this region masses of land of sufficient area and height to feed important rivers.[1] From currents of any other kind we are precluded, so that I believe we may safely turn our eyes northward and look for the ultimate source of the Triassic sandstones and conglomerates among the older rocks of the Scotch highlands, and their extension to east and to west, though very probably the materials may have been more directly supplied from Old Red Sandstone and early Carboniferous strata, in remnants of which identical fragments may still be seen. In like way we may regard the Trias of the south of England as the detritus of at least one great river, which flowed from the west or south-west. The materials of the Keuper came from the same directions in each case, but here, I think, we have indications of deposition in an inland sea. Breccias formed on its coasts, and sands were at first deposited in it; but presently the area of water increased, and the coarser materials must have been arrested in the uplands, while the fine sediment which forms the marls may have been carried out into the salt lake and slowly settled down in its calm waters.[2] Its shores may have been hardly more favourable to a vigorous development of life than were its salt-saturated waters; during this period and the preceding Bunter the lowland border of the mountains, like some of the northern districts of India, may have been arid and barren regions of shifting sands.

The Trias of Northern Scotland very probably indicates a repetition on a more restricted scale of the physical conditions of the Old Red Sandstone, but after this we observe signs of an encroachment of the Atlantic on the above-named old area of continental land.

The Jurassic series is represented in Northern Scotland on both the western and eastern coasts by marine or estuarine beds. This probably indicates important modifications in the river channels, subsidence on the west altering the slopes, reducing the length, and cutting away some of the feeding-ground. Traces may still be discerned in England of the two northern rivers, but that which in Triassic times was the larger contributor, appears in Jurassic to have been gradually enfeebled; the other one and the south-western stream seem to have still flowed with some strength. Sands, however, now become comparatively local. Probably the coarser materials, as a rule, did not reach the sea. This appears at all times to have been comparatively shallow and inclosed by land on every side but the south-east. The recent discovery of Oxford Clay beneath the Cretaceous beds at Chatham suggests that a narrow strait running in a northerly direction may have insulated the Palæozoic rocks

[1] Compare also the Bunter and Keuper in the region traversed by the German Rhine.

[2] The analogy of the Indian conglomerates was suggested to me by Dr. Blanford. See *Geol. Mag.* Dec. 2, vol. x. p. 514.

[1] It may be useful to give a rough idea of the quantity of rock which must have been denuded in order to obtain materials for the Bunter beds. Suppose, for purposes of calculation, we consider the Bunter beds, which cover the district from the Cheshire coast to the Midland counties, as forming the section of a cone contained by two planes drawn through the axis so as to include an angle of 30°. If $h$ be the height of this axis, and $r$ the radius of the base, the volume of this figure is $\frac{\pi r^2 h}{36}$. Take, for purposes of rough calculation, $h = \frac{1}{4}$ mile, $r = 80$ miles, $\pi = 3$; the volume is about 133 cubic miles. Conceive this piled up to form a long mound, in section an isosceles triangle 1 mile high, with a base of 4 miles. The length would be over 65 miles. Thus the materials buried in the Bunter beds of the above-named district represent a chain of hills unfurrowed by valleys 5000 feet high, 4 miles wide, and 65 miles long. Suppose the Pebble Bed, a like slice of a cone, axis one-tenth of a mile, base 70 miles; the volume is more than 40 cubic miles. Suppose the quartz and quartzite pebbles one-tenth of its volume; these represent a mass of 4 cubic miles, or a line of hills like the above 1000 feet high, 2 miles wide, and 20 long.

[2] The lake may have gradually become salt, or possibly the Muschelkalk sea may have for a short space invaded Britain, and then have been insulated like the Caspian.

beneath the London district. The clays of the Lias, Oxfordian, and Kimmeridgian probably indicate a direct discharge of sediment into the sea,[1] the limestones, depression sufficing to convert valleys into fjords, in the upper parts of which sediment was deposited so that the waters of the sea were clear. The deposits of the Purbeck and Weald indicate that the western river still drained an extensive area, and a gradual rise of land in later Jurassic times, especially towards the south, appears to have advanced the river delta eastwards, and to have limited the area of the Jurassic sea on the north.

Towards the end of the Neocomian, owing to a widespread subsidence, the sea once more returned to South-Eastern England, and a communication appears to have been opened between it and the Speeton basin. This comparatively narrow strait was a region of considerable denudation and of strong and shifting coast currents.[2] The Cretaceous subsidence at first brought back physical conditions not very different from those prevalent in Oxfordian and Kimmeridgian times, but later on a very considerable depression must have so far submerged the northern continental land as either to break up the parts adjacent to Britain into groups of islands, or at least to flood the valleys so completely as to prevent any discharge of sediment into the sea. The erratics of the Cambridge Greensand suggest that a free communication into the northern ocean was established, anterior to the formation of the Chalk marl, through some part of the present interval between Scotland and Scandinavia, so as to set up a coast current with a southerly drift of shore ice near the eastern part of England; to this also may be due the erosion of the Cambridgeshire Gault.

The larger part of Britain was dry land during the Eocene, though the sea after retreating appears to have again encroached over the southern and eastern districts of England. The sands may indicate that the western river again resumed its course;[3] the extension of the London Clay up our eastern coast suggests that the northern river still flowed. But with the important disturbances which closed the Eocene and ushered in the continental conditions of the Miocene—new flexures along the old east and west lines—the earlier physical features appear to have been finally obliterated, and the sculpture of the English lowlands began. The tale of the volcanic outbursts of Western Scotland has been so well told by my friend and predecessor Prof. Judd that I need do no more than recall it to your minds. The Pliocene deposits of Eastern England indicate a new encroachment of the Franco-Belgian Tertiary sea.

Thus ends my sketch, too lengthy, I fear, for your patience, yet too brief to allow of a complete treatment of the subject. It may, however, suffice to indicate that in geology the "task of the least" is by no means despicable, and that great results may be hoped from apparently small means; that in this search for "Atlantis through the microscope" we may find it very near at hand, and may discover analogies, as has been indicated in our President's address, between the two borders of the ocean which severs Europe from America. An enlarged study of the materials of our Palæozoic and later detrital rocks may indicate that from very early times there has been a recurrence of similar physical conditions, and that in geology also a recurrence of effects indicates a recurrence of the same causes. The facts which I have brought before you have justified, I trust, my opening remarks as to the rich harvest which yet awaits investigations into the structure of the fragmental rocks. To resume the simile then used, I see the land of promise, stretching far away from beneath my feet, till it seems to melt into the dim and as yet unknown distance. Not speedily will its riches be exhausted. Our hands will long have vanished, our voices will long have been still, before the work of discovery is ended, and men have reached the shore of that circumfluent ocean which, at least in this life, limits their finite powers.

[1] The considerable distance to which the clays extend in a southerly direction may possibly indicate that, to the east of Scotland, a communication had now been opened with the northern ocean, which had set up a current along the coast east of the Pennine Chain.

[2] As the Speeton beds continue to be clays, one would infer a drift from the south, but a current to the opposite direction would be more probable, and it is the opinion of Dr. Sorby that this was the case. His papers "On the Direction of the Currents indicated by the Coarse Sediments in our British Rocks" are most valuable (*Yorks. Geol. Pol. Soc.* v. 220, &c.).

[3] The occasional beds of flint pebbles indicate a neighbouring shore line of Cretaceous rocks rather than the denudation of beds of Cretaceous age, which had been deposited on parts of the western land during the period of depression.

## SECTION D

### BIOLOGY

OPENING ADDRESS BY WILLIAM CARRUTHERS, PRES.L.S., F.R.S., F.G.S., PRESIDENT OF THE SECTION

IN detaining you a few minutes from the proper work of the Section, I propose to ask your attention to what is known of the past history of the species of plants which still form a portion of the existing flora. The relation of our existing vegetation to preceding floras is beyond the scope of our present inquiry: it has been frequently made the subject of exposition, but to handle it requires a more lively imagination than I can lay claim to, or, perhaps, than it is desirable to employ in any strictly scientific investigation.

The literature of science is of little, if any, value in tracing the history of species, and in determining the modification or the persistency of characters which may be essential or accidental to them. If help could be obtained from this quarter, botanical inquiry would be specially favoured, for the literature of botany is earlier, and its terms have all along been more exact than in any of her sister sciences. But even the latest descriptions, incorporating as they do the most advanced observations of science, and expressed in the most exact terminology, fail to supply the data on which a minute comparison of plants can be instituted. Any attempt to compare the descriptions of Linnæus and the earlier systematists who, under his influence, introduced greater precision into their language, with the standard authors of our own day, would be of no value. The short, vague, and insufficient descriptions of the still earlier botanists cannot even be taken into consideration.

Greater precision might be expected from the illustrations that have been in use in botanical literature from the earliest times; but these really supply no better help in the minute study of species than the descriptions which they are intended to aid. The earliest illustrations are extremely rude: many of them are misplaced; some are made to do duty for several species, and not a few are purely fictitious. The careful and minutely exact illustrations which are to be found in many modern systematic works are too recent to supply materials for detecting any changes that may have taken place in the elements of a flora.

But the means of comparison which we look for in vain in the published literature of science may be found in the collections of dried plants which botanists have formed for several generations. The local herbaria of our own day represent not only the different species found in a country, but the various forms which occur, together with their distribution. They must supply the most certain materials for the minute comparison at any future epoch of the then existing vegetation with that of our own day.

The preservation of dried plants as a help in the study of systematic botany was first employed in the middle of the sixteenth century. The earliest herbarium of which we have any record is that of John Falconer, an Englishman who travelled in Italy between 1540 and 1547, and who brought with him to England a collection of dried plants fastened in a book. This was seen by William Turner, our first British botanist, who refers to it in his "Herbal," published in 1551. Turner may have been already acquainted with this method of preserving plants, for in his enforced absence from England he studied at Bologna under Luca Ghini, the first Professor of Botany in Europe, who, there is reason to believe, originated the practice of making herbaria. Ghini's pupils, Aldrovandus and Cæsalpinus, formed extensive collections. Caspar Bauhin, whose "Prodromus" was the first attempt to digest the literature of botany, left a considerable herbarium, still preserved at Basle. No collection of English plants is known to exist older than the middle of the seventeenth century; a volume containing some British and many exotic plants collected in the year 1647 was some years ago acquired by the British Museum. Towards the end of that century great activity was manifested in the collection of plants, not only in our own country, but in every district of the globe visited by travellers. The labours of Ray and Sloane, of Petiver and Plukenet are manifest not only in the works which they published, but in the collections that they made, which were purchased by the country in 1759 when the museum of Sir Hans Sloane became the nucleus of the now extensive collections of the British Museum. The most important of these collections in regard to British plants is the herbarium of Adam Buddle, collected nearly 200 years ago, and containing an extensive series, which formed the basis of a

British flora, that unhappily for science was never published, though it still exists in manuscript. Other collections of British plants of the same age, but less complete, supplement those of Buddle: these various materials are in such a state of preservation as to permit of the most careful comparison with living plants, and they show that the two centuries which have elapsed since their collection have not modified in any particular the species contained in them. The early collectors contemplated merely the preservation of a single specimen of each species; consequently the data for an exhaustive comparison of the indigenous flora of Britain at the beginning of last century with that of the present are very imperfect as compared with those which we shall hand down to our successors for their use.

The collections made in other regions of the world in the seventeenth century, and included in the extensive herbarium of Sir Hans Sloane, are frequently being examined side by side with plants of our own day, but they do not show any peculiarities that distinguish them from recent collections. If any changes are taking place in plants, it is certain that the 300 years during which their dried remains have been preserved in herbaria have been too short to exhibit them.

Beyond the time of those early herbaria the materials which we owe in any way to the intervention of man have been preserved without any regard to their scientific interest. They consist mainly of materials used in building or for sepulture. The woods employed in mediæval buildings present no peculiarities by which they can be distinguished from existing woods; neither do the woods met with in Roman and British villages and burying-places. From a large series collected by General Pitt-Rivers in extensive explorations carried on by him on the site of a village which had been occupied by the British before and after the appearance of the Romans, we find that the woods chiefly used by them were oak, birch, hazel, and willow, and at the latter period of occupation of the village the wood of the Spanish chestnut (*Castanea vulgaris*, Lamk.) was so extensively employed that it must have been introduced and grown in the district. The gravel beds in the north of London, explored by Mr. W. G. Smith for the palæolithic implements in them, contained also fragments of willow and birch, and the rhizomes of *Osmunda regalis*, L.

The most important materials, however, for the comparison of former vegetation of a known age with that of our own day have been supplied by the specimens which have been obtained from the tombs of the ancient Egyptians. Until recently these consisted mainly of fruits and seeds. These were all more or less carbonised, because the former rifling of the tombs had exposed them to the air. Ehrenberg, who accompanied Von Minutoli in his Egyptian expedition, determined the seeds which he had collected; but as he himself doubted the antiquity of some of the materials on which he reported, the scientific value of his enumeration is destroyed. Passalacqua in 1823 made considerable collections from tombs at Thebes, and these were carefully examined and described by the distinguished botanist Kunth. He pointed out, in a paper published sixty years ago, that these ancient seeds possessed the minute and apparently accidental peculiarities of their existing representatives. Unger, who visited Egypt, published in several papers identifications of the plant remains from the tombs; and one of the latest labours of Alexander Braun was an examination of the vegetable remains in the Egyptian Museum at Berlin, which was published, afer his death, from his manuscript, under the careful editorship of Ascherson and Magnus. In this, twenty-four species were determined, some from imperfect materials, and necessarily with some hesitation as to the accuracy of their determination.

The recent exploration of unopened tombs belonging to an early period in the history of the Egyptian people has permitted the examination of the plants in a condition which could not have been anticipated. And happily, the examination of these materials has been made by a botanist who is thoroughly acquainted with the existing flora of Egypt, for Dr. Schweinfurth has for a quarter of a century been exploring the plants of the Nile valley. The plant-remains were included within the mummy-wrappings, and, being thus hermetically sealed, have been preserved with scarcely any change. By placing the plants in warm water, Dr. Schweinfurth has succeeded in preparing a series of specimens gathered 4000 years ago, which are as satisfactory for the purposes of science as any collected at the present day. These specimens consequently supply means for the closest examination and comparison with their living representatives. The colours of the flowers are still present, even the most evanescent, such as the violet of the larkspur and knapweed, and the scarlet of the poppy; the chlorophyll remains in the leaves, and the sugar in the pulp of the raisins. Dr. Schweinfurth has determined no less than fifty-nine species, some of which are represented by the fruits employed as offerings to the dead, others by the flowers and leaves made into garlands, and the remainder by branches on which the body was placed, and which were inclosed within the wrappings.

[The following is a list of the species of ancient Egyptian plants determined by Dr. Schweinfurth; I am indebted to Dr. Schweinfurth for some species in this list, the discovery of which he has not yet published:—*Delphinium orientale*, Gay; *Cocculus Leæba*, DC.; *Nymphæa cœrulea*, Sav.; *Nymphæa Lotus*, Hook.; *Papaver Rhœas*, L.; *Sinapis arvensis*, L., var. *Allionii*, Jacq.; *Mærua uniflora*, Vahl.; *Oncoba spinosa*, Forsk.; *Tamarix nilotica*, Ehrb.; *Alcea ficifolia*, L.; *Linum humile*, Mill.; *Balanites ægyptiaca*, Del.; *Vitis vinifera*, L.; *Moringa aptera*, Gærtn.; *Medicago denticulata*, Willd.; *Sesbania ægyptiaca*, Pers.; *Faba vulgaris*, Mœnch; *Lens esculenta*, Mœnch; *Lathyrus sativus*, L.; *Cajanus indicus*, L.; *Acacia nilotica*, Del.; *Lawsonia inermis*, Lamk.; *Punica Granatum*, L.; *Epilobium hirsutum*, L.; *Lagenaria vulgaris*, Ser.; *Citrullus vulgaris*, Schrad., var. *colocynthoides*, Schweinf.; *Apium graveolens*, L.; *Coriandrum sativum*, L.; *Ceruana pratensis*, Forsk.; *Sphæranthus suaveolens*, DC.; *Chrysanthemum coronarium*, L.; *Centaurea depressa*, M. Bieb.; *Carthamus tinctorius*, L.; *Picris coronopifolia*, Asch.; *Mimusops Schimperi*, Hochst.; *Jasminum Sambac*, L.; *Olea europæa*, L.; *Mentha piperita*, L.; *Rumex dentatus*, L.; *Ficus Sycomorus*, L.; *Ficus Carica*, L.; *Salix Safsaf*, Forsk.; *Juniperus phœnicea*, L.; *Pinus Pinea*, L.; *Allium sativum*, L.; *Allium Cepa*, L.; *Phœnix dactylifera*, L.; *Calamus fasciculatus*, Roxb.; *Hyphæne thebaica*, Mart.; *Medemia Argun*, P. G. von Würtemb.; *Cyperus Papyrus*, L.; *Cyperus esculentus*, L.; *Andropogon laniger*, Desf.; *Leptochloa bipinnata*, Retz.; *Triticum vulgare*, L.; *Hordeum vulgare*, L.; *Parmelia furfuracea*, Ach.; *Usnea plicata*, Hoffm.]

The votive offerings consist of the fruits, seeds, or stems, of twenty-nine species of plants. Three palm fruits are common: the *Medemia Argun*, Würt., of the Nubian Desert, and the *Hyphæne thebaica*, Mart., of Upper Egypt, agreeing exactly with the fruits of these plants in our own day; also dates of different forms resembling exactly the varieties of dried dates found now in the markets of Egypt. Two figs are met with, *Ficus Carica*, L., and *Ficus Sycomorus*, L., the latter exhibiting the incisions still employed by the inhabitants for the destruction of the Neuropterous insects which feed on them. The sycamore was one of the sacred trees of Egypt, and the branches used for the bier of a mummy found at Abd-el-Qurna, of the twentieth dynasty (a thousand years before the Christian era), were moistened and laid out by Dr. Schweinfurth, equalling, he says, the best specimen of this plant in our herbaria, and consequently permitting the most exact comparison with living sycamores, from which they differ in no respect. The fruit of the vine is common, and presents, besides some forms familiar to the modern grower, others which have been lost to cultivation. The leaves which have been obtained entire exactly agree in form with those cultivated at the present day, but the under surface is clothed with white hairs, a peculiarity Dr. Schweinfurth has not observed in any Egyptian vines of our time. A very large quantity of linseed was found in a tomb at Thebes of the twentieth dynasty, now 3000 years old, and a smaller quantity in a vase in another tomb of the twelfth dynasty, that is, 1000 years older. This belongs certainly to *Linum humile*, Mill., the species still cultivated in Egypt, from which the capsules do not differ in any respect. Braun had already determined this species preserved thus in the tombs, though he was not aware of its continued cultivation in Egypt. The berries of *Juniperus phœnicea*, L., are found in a perfect state of preservation, and present a somewhat larger average size than those obtained from this juniper at the present day. Grains of barley and wheat are of frequent occurrence in the tombs; M. Mariette has found barley in a grave at Sakhara of the fifth dynasty, 5400 years old.

The impurities found with the seeds of these cultivated plants show that the weeds which trouble the tillers of the soil at the present day in Egypt were equally the pests of their ancestors in those early ages. The barley-fields were infested with the same spiny medick (*Medicago denticulata*, Willd.) which is still found in the grain crops of Egypt. The presence of the pods

of *Sinapis arvensis*, L., among the flax seed testifies to the presence of this weed in the flax crops of the days of Pharaoh, as of our own time. There is not a single field of flax in Egypt where this charlock does not abound, and often in such quantity that its yellow flowers, just before the flax comes into bloom, present the appearance of a crop of mustard. The charlock is *Sinapis arvensis*, L., var. *Allionii*, Jacq., and is distinguished from the ordinary form by its globular and inflated silicules, which are as characteristically present in the ancient specimens from the tombs as in the living plants. *Rumex dentatus*, L., the dock of the Egyptian fields of to-day, has been found in graves of the Greek period at Dra-Abu-Negga.

It is difficult without the actual inspection of the specimens of plants employed as garlands, which have been prepared by Dr. Schweinfurth, to realise the wonderful condition of preservation in which they are. The colour of the petals of *Papaver Rhœas*, L., and the occasional presence of the dark patch at their bases present the same peculiarities as are still found in this species growing in Egyptian fields. The petals of the larkspur (*Delphinium orientale*, Gay) not only retain their reddish-violet colour, but present the peculiar markings which are still found in the living plant. A garland composed of wild celery (*Apium graveolens*, L.) and small flowers of the blue lotus (*Nymphæa cærulea*, Sav.), fastened together by fibres of papyrus, was found on a mummy of the twentieth dynasty, about three thousand years old. The leaves, flowers, and fruits of the wild celery have been examined with the greatest care by Dr. Schweinfurth, who has demonstrated in the clearest manner their absolute identity with the indigenous form of this species now abundant in moist places in Egypt. The same may be said of the other plants used for garlands, including two species of lichens.

It appears to have been a practice to lay out the dead bodies on a bier of fresh branches, and these were inclosed within the linen wrappings which enveloped the mummy. In this way there have been preserved branches of considerable size of *Ficus Sycomorus*, L., *Olea europæa*, L., *Mimusops Schimperi*, H., and *Tamarix nilotica*, Ehrb. The Mimusops is of frequent occurrence in the mural decorations of the ancient temples; its fruit had been detected amongst the offerings to the dead, and detached leaves had been found made up into garlands, but the discovery of branches with their leaves still attached, and in one case with the fruit adhering, has established that this plant is the Abyssinian species to which Schimper's name has been given, and which is characterised by the long and slender petiole of the leaf.

In none of the species, except the vine to which I have referred, which Dr. Schweinfurth has discovered, and of which he has made a careful study, has he been able to detect any peculiarities in the living plants which are absent in those obtained from the tombs.

Before passing from these Egyptian plants I would draw attention to the quality of the cereals. They are good specimens of the cereals still cultivated. This observation is true also of the cultivated grains which I have examined, belonging to prehistoric times. The wheat found in the purely British portion of the ancient village explored by General Pitt-Rivers is equal to the average of wheat cultivated at the present day. This is the more remarkable, because the two samples from the later Romano-British period obtained by General Pitt-Rivers are very much smaller, though they are not unlike the small hard grains of wheat still cultivated on thin chalk soils. The wheat from lake-dwellings in Switzerland, for which I am indebted to Mr. J. T. Lee, F.G.S., are fair samples. My colleague, Mr. W. Fawcett, has recently brought me, from America, grains of maize from the prehistoric mounds in the valley of the Mississippi, and from the tombs of the Incas of Peru, which represent also fair samples of this great food substance of the New World. The early peoples of both worlds had then under cultivation productive varieties of these important food-plants, and it is remarkable that in our own country, with all the appliances of scientific cultivation and intelligent farming, we have not been able to appreciably surpass the grains which were harvested by our rude ancestors of 2000 years ago.

In taking a further step into the past, and tracing the remains of existing species of plants preserved in the strata of the earth's crust, we must necessarily leave behind all certain chronology. Without an intelligent observer and recorder there can be no definite determination of time. We can only speculate as to the period required for effecting the changes represented by the various deposits.

The peat-bogs are composed entirely of plant-remains belonging to the floras existing in the regions where they occur. They are mainly surface-accumulations still being formed and going back to an unknown antiquity. They are subsequent to the last changes in the surface of the country, and represent the physical conditions still prevailing.

The period of great cold during which Arctic ice extended far into temperate regions was not favourable to vegetable life. But in some localities we have stratified clays with plant-remains later than the Glacial epoch, yet indicating that the great cold had not then entirely disappeared. In the lacustrine beds at Holderness is found a small birch (*Betula nana*, L.), now limited in Great Britain to some of the mountains of Scotland, but found in the Arctic regions of the Old and New World and in Alpine districts in Europe, and with it *Prunus Padus*, L., *Quercus Robur*, L., *Corylus Avellana*, L., *Alnus glutinosa*, L., and *Pinus sylvestris*, L. In the white clay beds at Bovey Tracey of the same age there occur the leaves of *Arctostaphylos Uva-Ursi*, L., three species of willow, viz. *Salix cinerea*, L., *S. myrtilloides*, L., and *S. polaris*, Wahl., and in addition to our alpine *Betula nana*, L., the more familiar *B. alba*, L. In beds of the same age in Sweden, Nathorst has found the leaves of *Dryas octopetala*, L., and *Salix herbacea*, L., this being associated with *S. polaris*, Wahl. Two of these plants have been lost to our flora from the change of climate that has taken place, viz. *Salix myrtilloides*, L., and *S. polaris*, Wahl.; and *Betula nana*, L., has retreated to the mountains of Scotland. Three others (*Dryas octopetala*, L., *Arctostaphylos Uva-Ursi*, L., and *Salix herbacea*, L.), have withdrawn to the mountains of Northern England, Wales, and Scotland, while the remainder are still found scattered over the country. Notwithstanding the diverse physical conditions to which these plants have been subjected, the remains preserved in these beds present no characters by which they can be distinguished from the living representatives of the species.

We meet with no further materials for careful comparison with existing species until we get beyond the great period of intense cold which immediately preceded the present order of things. The Glacial epoch includes four periods during which the cold was intense, separated by intervals of somewhat higher temperature, which are represented by the intervening sedimentary deposits. During these alterations of temperature, extensive changes in the configuration of the land were taking place. The first great upheaval occurred in the early Glacial period, and was followed by a considerable subsidence. A second upheaval took place late in the Glacial epoch. Various estimates have been formed of the time required for this succession of climatic conditions and earth-movements. The moderate computation of Ramsay and Lyell gives to the boulder-clay of the first Glacial period an age of 250,000 years, estimating the time of the first upheaval as 200,000 years ago, while the subsidence took place 50,000 years later, and the second upheaval 92,000 years ago.

The sedimentary deposits later than the Pliocene strata, but older than the Glacial drift, indicate an increasing severity in the climate, which reached its height in the first Glacial period.

At Cromer, on the Norfolk coast, the newest of these deposits has supplied the remains of *Salix polaris*, Wahl., *S. cinerea*, L., and *Hypnum turgescens*, Schimp. This small group of plants is of great interest in connection with the history of existing species; their remains are preserved in such a manner as to permit the closest comparison with living plants. Such an examination shows that they differ from each other in no particular. In the post-Glacial deposits in Sweden, *Salix herbacea*, L., is associated with *S. polaris*, Wahl., as I have already stated. These two willows are very closely related, having indeed been treated as the same species until Wahlenberg pointed out the characters which separated them when he established *Salix polaris* as a distinct species in 1812. One of the most obvious of the specific distinctions is the form and venation of the leaf, a character which is, however, easily overlooked, but when once detected is found to be so constant that it enables one to distinguish without hesitation the one species from the other. The leaves of the two willows in the Swedish bed present all the peculiarities which they possess at the present day, and the venation and form of the leaves of *S. polaris*, Wahl., from the pre-Glacial beds of Cromer, present no approach towards the peculiarities of its ally *S. herbacea*, L., but exhibit them exactly as they appear in the living plant. This is the more noteworthy as the vegetative organs supply, as a rule, the least stable of the

characters employed in the diagnosis of species. The single moss (*Hypnum turgescens*, Schimp.) is no longer included in the British flora, but is still found as an Arctic and Alpine species in Europe, and the pre-Glacial specimens of this cellular plant differ in no respect from their living representatives.

The older beds containing the remains of existing species, which are found also at Cromer, have recently been explored with unwearied diligence and great success by Mr. Clement Reid, F.G.S., an officer of the Geological Survey of England. To him I am indebted for the opportunity of examining the specimens which he has found, and I have been able to assist him in some of his determinations, and to accept all of them. His collections contain sixty-one species of plants belonging to forty-six different genera, and of these forty-seven species have been identified. Slabs of clay-ironstone from the beach at Happisburgh contain leaves of beech, elm, oak, and willow. The materials, however, which have enabled Mr. Reid to record so large a number of species are the fruits or seeds which occur chiefly in mud or clay, or in the peat of the forest bed itself. The species consist mainly of water or marsh plants, and represent a somewhat colder temperature than we have in our own day, belonging as they do to the Arctic facies of our existing flora.

Only one species (*Trapa natans*, L.), has disappeared from our islands; its fruits, which Mr. Reid found abundantly in one locality, agree with those of the plants found until recently in the lakes of Sweden. Four species (*Prunus spinosa*, L., *Œnanthe Lachenalii*, Gmel., *Potamogeton heterophyllus*, Schreb., and *Pinus Abies*, L.) are found at present only in Europe, and a fifth (*Potamogeton trichoides*, Cham.) extends also to North America; two species (*Peucedanum palustre*, Mœnch, and *Pinus sylvestris*, L.) are found also in Siberia, whilst six more (*Sanguisorba officinalis*, L., *Rubus fruticosus*, L., *Cornus sanguinea*, L., *Euphorbia amygdaloides*, L., *Quercus Robur*, L., and *Potamogeton crispus*, L.) extend into Western Asia, and two (*Fagus sylvatica*, L., and *Alnus glutinosa*, L.) are included in the Japanese flora. Seven species, while found with the others, enter also into the Mediterranean flora, extending to North Africa: these are *Thalictrum minus*, L., *Thalictrum flavum*, L., *Ranunculus repens*, L., *Stellaria aquatica*, Scop., *Corylus Avellana*, L., *Zannichellia palustris*, L., and *Cladium Mariscus*, Br. With a similar distribution in the Old World, eight species (*Bidens tripartita*, L., *Myosotis cæspitosa*, Schultz, *Suæda maritima*, Dum., *Ceratophyllum demersum*, L., *Sparganium ramosum*, Huds., *Potamogeton pectinatus*, L., *Carex paludosa*, Good., and *Osmunda regalis*, L., are found also in North America. Of the remainder, ten species (*Nuphar luteum*, Sm., *Menyanthes trifoliata*, L., *Stachys palustris*, L., *Rumex maritimus*, L., *Rumex Acetosella*, L., *Betula alba*, L., *Scirpus pauciflorus*, Lightf., *Taxus baccata*, L., and *Isoetes lacustris*, L.-extend round the north temperate zone, while three (*Lycopus europæus*, L., *Alisma Plantago*, L., and *Phragmites communi*,) Trin.), having the same distribution in the north, are found also in Australia, and one (*Hippuris vulgaris*, L.) in the south of South America. The list is completed by *Ranunculus aquatilis*, L., distributed over all the temperate regions of the globe, and *Scirpus lacustris*, L., which is found in many tropical regions as well.

The various physical conditions which necessarily affected these species in their diffusion over such large areas of the earth's surface in the course of, say, 250,000 years, should have led to the production of many varieties, but the uniform testimony of the remains of this considerable pre-Glacial flora, as far as the materials admit of a comparison, is that no appreciable change has taken place.

I am unable to carry the history of any existing species of plant beyond the Cromer deposits. Some of the plant-remains from Tertiary strata have been referred to still living species, but the examination of the materials, as far as they have come before me, convinces me that this has been done without sufficient evidence. The physical conditions existing during even the colder of the Tertiary periods were not suitable to a flora fitted to persist in these lands in our day, even if the period of great cold had not intervened to destroy them. And in no warmer region of the earth do these Tertiary species now exist, though floras of the same facies occur, containing closely allied species. The sedimentary beds at the base of the Glacial epoch contain, as far as we at present know, the earliest remains of any existing species of plant.

It is not my purpose to point out the bearing of these facts on any theoretical views entertained at the present day: I wish merely to place them before the members of this Section as data which must be taken into account in constructing such theories, and as confirming the long-established axiom that by us, at least, as workers, species must be dealt with as fixed quantities.

## SECTION H

### ANTHROPOLOGY

OPENING ADDRESS BY SIR GEORGE CAMPBELL, K.C.S.I., M.P., D.C.L., F.R.G.S., PRESIDENT OF THE SECTION.

I FEEL much diffidence in taking this chair, for, though in former days I used to pay a good deal of attention to what was then called ethnology, I have been for many years immersed in perhaps more exciting but, I am afraid, less satisfactory occupations; and I feel that I am very far behind in scientific knowledge and scientific methods. I only venture to address you because I take for my subject practical, rather than scientific, anthropology; the study and cultivation of the creature man as he exists, rather than that branch of the subject which seeks to inquire into his origin and development. Intensely interesting as are inquiries into the origin of man, it must be admitted that our knowledge on the subject is still very limited and our progress slow; that we have not yet got hold of the missing link, and scarcely know whether the flint implements are the work of man or of some earlier intelligent creature. We are hardly on firm ground till we come to man very much in the form in which we now have him, and even already divided into the principal varieties which exist to this day. I now then invite you to approach the subject rather as practical agriculturists deal with the subject of horses and cattle than as scientists who trace these animals to very ancient prehistoric types; and in dealing with man from this point of view I am emboldened by the consideration that here also science has not yet completely conquered the field, and that very much is open to those who bring to it only a quick eye and careful observation. I think it can hardly be doubted that, in distinguishing well-marked types of humanity, the eye is after all the easiest and perhaps the safest guide. With that alone one can recognise the unmistakable differences of colour, size, facial features, set of the eye, character of the hair, and one or two other features by which the physical characters of different types of humanity are varied. On the other hand, when we come to nicer and more subtile distinctions, especially among the mixed races which occupy most of the world, we must confess that anthropometric science as applied to craniology, &c., gives us results only partially conclusive. I have an unusually narrow head. I can hardly be fitted with a hat without making the hatter elongate it; my next brother has so remarkably broad a head that he cannot be fitted without altering a large hat the other way: and so I think it is in many families and races, as any one who tries to puzzle out craniological results will find.

So again as regards other guides to race. It is admitted that language is not always a safe guide, but still it is a very important element in ethnological inquiries, especially among primitive races. I have paid some attention to that, and my impression is strong that language tests of race are to be found in the few simple elementary words and forms which any observer can easily master and examine, and not in the higher developments of the language, which are generally much intermixed with and influenced by foreign elements. I roughly put together a few dozen test words, &c., which we found very efficacious in India. Take English, too; the origin of the race is found in the lower and monosyllabic words, though the majority of the English words in a dictionary are Latin and French.

There is another race-guide which requires much care and some scientific accuracy, though not of what we should call a properly anthropometric character—I mean laws, customs, and habits. Like language these too may be varied by foreign influences, but I incline to think that they are more important for our purposes than has always been recognised, and are at least as persistent as, perhaps more persistent than, language. At any rate, they are certainly most important as affecting the modern history and cultivation of man; and while some laws and customs require scientific study, many habits and practices are on the surface, and open to the observation of every intelligent observer. I might class food and drink among such habits, as being those which bear most directly of all on physical

development. For instance, one scarcely realises till one goes to China how important is the cow as pre-eminently an Aryan animal, the early sacredness of which was founded upon uses almost ignored by other great races, such as the Chinese. The Chinese, again, who will not touch milk, and reject some other food which we think among the best (pheasants, for instance), make constant and large use of food which we reject, such as puppies and rats. It is most interesting to inquire whether there is any foundation for either class of prejudices.

Among other habits and institutions well worthy of observation I might cite marriage and the family descent, through the female or through the male, the forms of small self-governing communities, and the tenure of land. Animals of nearly allied species seem to be divided by curiously sharp lines into polygamous and monogamous races. It is hard to understand why hares should be strictly monogamous, rabbits polygamous, partridges monogamous, pheasants polygamous, geese monogamous, ducks polygamous. We have yet to discover to which class man belonged before laws divided the race into two opposite camps in this matter. When we come to institutions and land tenure we approach the region of politics, but for my part I must at once say that, if we avoid mere party in politics, we anthropologists are called on to perform most important functions in the social politics of the day. What can be more important than to ascertain the effect on the race of modern urban life, of the increased use of meat, of the diminished use of milk, of the enormously increased consumption of tea, of the more constant use of the eyes and the brain, viewing these subjects in their broad general results, rather than from a merely medical point of view?

My view of the good work that may be done by the more popular methods in anthropology may be somewhat consoling to our countrymen generally, for they seem as a whole to be too busy for much science, and to be deficient in it. I see it was stated that we have to get anthropometric instruments from abroad. But on the other hand our opportunies for observation far outrival all others. In our vast Empire we have every race, and every shade, every stage of progress, from the lowest to the highest; every institution and every method of living. As rulers, as explorers, as merchants, as employers of labour, as colonists, we come into the nearest contact, and have the most intimate relations with almost every people and every tribe on the face of the earth. We are indeed a people who, if we make but the most moderate use of opportunities, may bring together such a mass of knowledge of mankind as to leave nothing wanting. Surely then in this country anthropology is no mean subject.

Both in regard to the greatness of our dominion, the vastness of the population, and its infinite variety, India is by far the greatest of our fields, as it is that in which we have the most complete and effective official machinery. India is remarkable not only for its many countries, climates, and races, but also for the division of the populations into what one may call horizontal strata. There, under the caste system, every rank, occupation, and profession represents in some sort a race, and that in enormous variety. Whatever infiltration of blood there may be, every caste in India is at least as much a peculiar and separate race as were till lately Jews or gipsies in our own country, and more so. Every one of them has, too, its own institutions, its own rules of marriage and inheritance, its own laws and customs; and I need scarcely add that outside this Hindoo agglomeration of many races there are the various aboriginal races—also in great variety, and in a state of excellent preservation—tribes not of one family of the human race, but of almost every great family, from the purest Aryans of the north-west to what I may call extreme Mongolians in the east, and primitive blacks in the centre and south.

In truth, my experience of that great anthropological field India is my excuse for sitting here to-day. It has been my fortune to serve in very many parts of that great country, and, so far as my scanty acquirements permit, I have always taken great interest in, and inquired much about, the races and varieties of the peoples; and I think I may claim this, too, that ever since I have been a good deal absorbed in politics, in all the travels I have made in several parts of the world, in Eastern Europe, in America, and elsewhere, I have never wholly forgotten my ethnological proclivities, and have pried about a good deal to pick up information regarding the various races and tribes.

As India is in some sense an epitome of the world, so I may also say that the last provinces I administered, those forming the Government of Bengal, are or were an epitome of India. At that time the whole of Assam and the eastern frontiers were under Bengal, and we certainly had a very much greater variety of races than any other province in India—perhaps I may say than any other country in the world. Among the more advanced races, besides the whole of the well-marked Bengalee nationality we had some twenty millions of Hindustanis on the north, the Ooryahs on the west, and the Assamese on the east; then of the Indian aboriginal races, while in other provinces they have but scanty hill tribes, counted by thousands, we have in the western districts of Bengal many millions of these aborigines, settled, comparatively civilised, a fecund, colonising, and migratory people; we have them in endless variety of both the great aboriginal families, the Dravidian and that now generally known as the Kolarian. Partly in the Central Provinces and partly in Bengal, it has indeed been my lot to administer the whole of what I may call "aboriginal India." I may here mention that the several aboriginal Dravidian tribes of this tract speak languages clearly Dravidian in their roots, and yet for the rest so distant from the cultivated Dravidian languages that the common origin must be very ancient indeed. But no one who sees these people can doubt their non-Caucasian character; and that may go far to settle the question whether the Dravidians of the Peninsula are of Caucasian origin, or non-Caucasians overlaid by an Aryan over-crust.

Again, on the north and east we have some forest tribes which may or may not be related to the aborigines of the interior of India. But as soon as we get into the hill country we meet with every form of what may be called the Indo-Chinese type—all the way from the frontiers of Nepal on the north, along the Eastern Himalayas, round both sides of Assam, and then on to Maneepore, the Chittagong hills, and the Burmese country. Here and there in this great extent of country we have many unclassed races with peculiar languages and institutions of their own—some very savage, others far advanced in civilisation. Among the latter I might mention, for instance, the Khassyahs, a very peculiar people with highly developed constitutional and elective forms of government, and also specially interesting as exhibiting far the best specimen of which I have anywhere heard of the matriarchal, or perhaps I should rather say matri-herital, system fully carried out under recognised and well-defined law among a civilised people. The result of observation of the Khassyahs has been to separate in my mind the two ideas of matri-heritage and polyandry, and to suggest that polyandry is really only a local accident, the result of scarcity of women; as, for instance, in some parts of the Himalayas, where the hill women are in great demand in the adjoining plains, and the hill men are obliged to be content with a reduced number of women. Among the Khassyahs, on the other hand, there is no polyandry (so far as I have been able to learn) though there is great facility for divorce; and heritage through the female becomes quite intelligible, I may say natural, when we see that the females do not leave the maternal home and family and join any other family, as do the Aryans. They are the stock-in-trade of the family, the queen bees as it were; they take to themselves husbands—only one at a time, and if he is divorced they may take another—but the husband is a mere outsider belonging to another family. The property of the woman goes in the woman's family, the property of the man in his own maternal family. It should be added, however, that in these maternal families, though the heritage comes through the female, the males rule, as they ought to in all well-ordered communities.

When I administered the Government of Bengal I did the best I could to obtain a classification of our many races, and a comparison of the languages brought together under my system of test words, and officially published in a large volume. We owe to the unrivalled experience of the late General Dalton a mass of information regarding the western aboriginal tribes, comprised in his great ethnological volume and many other publications; and more recently that very distinguished Indian officer, Mr. A. Mackenzie, partly a Scotchman and partly a Birmingham man, has brought together in his "North-East Frontier of Bengal" a full and most interesting account of the eastern tribes. Now I am happy to say that one of my old fellow-workers in Bengal, who at present most worthily and well administers the government of that province, has undertaken, through Mr. Risley, a much greater work than any of us have yet attempted, viz. a general survey of the whole people, not only as regards their physical characteristics and languages, &c., but also (and this is the newest and most important part of the undertaking) as regards their institutions, laws, and social rules.

It is hoped that, by obtaining accurate information of this kind regarding the many races, tribes, and castes of these great provinces, a flood of light may be thrown on the social history of the human race. It is a very great undertaking, but successfully carried out must have very great results. I can conceive nothing more important and interesting, and only hope that something of the kind may be attempted for India as a whole. Some of the most important castes, the Brahmins for instance, are so widely spread that we can hardly realise their position without extending the survey over India. In Bengal I think they are little agricultural, while in some provinces they are among the best of the agriculturists.

I could well wish that we had systematic inquiries of this kind nearer home. Europe is almost as good an anthropological field as India, and in our islands there is still very much room for investigation. In my own country of Scotland, after much asking, I have never been able to get any information who the Aberdonians are, and what is the language they speak, so different in its forms and intonations from the rest of Scotland. In England some most interesting maps might be made if it were only to trace the letter *h*, showing where it begins and where it ends. I have a belief that though languages may be changed and cease to indicate races, there is a great racial persistency in the letter *h* or the absence of it. The Scotch and the Irish have adopted the English language, but no Scotchman or Irishman was ever in the smallest degree wanting in aspirates—an Englishman might perhaps call them hyper-aspirators. The greater part of England, on the contrary, is equally persistent in the dropping of *h*'s. The whole subject is most interesting, not only in regard to the use or omission of the *h* by various races, but also on account of the very singular—I may say phenomenal—tendency of so many of the English neither to maintain nor to abandon the *h*, but simply to reverse the written language, omitting the *h* where it is written, and putting it in where it is not, in a peculiarly aggressive manner. It has been noticed, with truth, that we seem legitimately to drop the *h* in almost all words that come direct from the Latin, as "hour," "heir," "honour," yet in the Latin we pronounce the *h* fully. Is the spoken language the true tradition? Can it be that, while the Greeks spoke in aspirates which they did not write, the Romans clipped those which they did write, and that the modern Englishman combines the practice of these two famous races? Or is there any foundation for what I can call no more than a conjecture, viz. that the real English is that spoken by the Scotch, and that the corruption of the *h*'s is French brought in by the Normans? If a language map showed the clipping of *h*'s to be coincident with large Norman settlements, that might be so. Perhaps a few hundred years ago it was the aristocratic thing to clip the *h*'s, and the fashion may have gradually gone to the lower classes like the swallow-tailed coat worn by the typical Irish peasant, while the upper classes have been partially reformed back to true English by contact with the Scotch—only partially though, for they still say "wĕn" and "wāle" instead of "when" and "whale," to say nothing of "idear" and "Indiar."

This, however, is a digression. I am afraid I have been long in coming to the main object of this address, viz. to recommend the systematic and scientific cultivation of man—what I may call "homi-culture," in the same sense as "oyster-culture," "bee-culture," or "cattle-culture"—and that with a view both to physical and mental qualities. It seems very sad indeed, that, when so much has been done to improve and develop dogs, cattle, oysters, cabbages, nothing whatever has been done for man, and he is left very much where he was when we have the first authentic records of him. Knowledge, education, arts, he has no doubt acquired; but there seems to be no reason to suppose that the individual man is physically or mentally a superior creature to what he was five thousand years ago. We are not sure that under very modern influences he may not retrograde. No one doubts that, by careful selection and cultivation, cattle, vegetables, and many other things have been immensely improved. In regard to animals and plants we have very largely mastered the principles of heredity and culture, and the modes by which good qualities may be maximised, bad qualities minimised. Why should not man be similarly improved? It is true that the mind has a larger share in that which constitutes a man; but after all this is only a question of degree—the cultivation of the mind *does* enter very largely into animal-culture. I apprehend there is no doubt that the superiority for our purposes of shorthorns, black-polled, and other famous breeds of cattle is very largely due to placid and well-regulated minds, which enable them to take calmly a short and happy life, and to assimilate their food, differing in this very much from their restless and often vicious ancestors. Surely, then, if we only had the requisite knowledge, and, taking a practical view of life, could regulate our domestic arrangements with some degree of reason, rather than by habit, prejudice, and the foolish ideas cultivated by foolish novelists, man too might be greatly improved.

It may be admitted that we are not in a position to begin confident man-culture at once. Much study is first required and much knowledge must be accumulated before we can be confident in practice. The first thing that most strikes us in man, as compared with all domesticated and even most widely-spread wild animals, is the extremely small variation in man all over the globe. There are differences which seem large to us, but are extremely small from a more enlarged point of view. How enormous are the differences between different breeds of dogs, horses, and cattle! When we come to man the difference of which we make most is that of colour—a feature which we think quite trivial in animals. Who thinks very much more highly of a white than of a black cow, of a grey horse than of a black one? Our skilled eyes recognise variations of human feature, but they are so slight that the inhabitant of another planet would see no more difference than in the countenances of a flock of sheep. In size, compared to other animals, the differences are but slight. Probably there is no race whose average height really approaches six feet, and I doubt if any are on the average so small as five feet. In other physical features there are no considerable differences of formation whatever. Then as regards the mind we have yet to learn that there are very wide differences of mental capacity between different races. Very likely—probably, I may say—there are considerable variations, but they are not so wide as to be apparent without careful and accurate study. With the superficial knowledge we have, no one can say that Europeans, Hindus, Chinese, are born with brains superior or inferior to the other; and even in regard to the negro I do not know that it is yet shown that with equal advantages Negro babies might not grow up nearly or quite as intelligent as Europeans. I do not say that it is so, but only that the question has not yet been sufficiently worked out. The difference is not so radical as to be self-evident from the first. Still, such experience as we have and the analogies derived from domesticated animals both tend to the belief that there *are* considerable, if not excessive, variations in the qualities and capacities of different races of men.

It seems to me, then, that the first object to which observation and experiment should be directed is to ascertain how far the qualities which distinguish different races, peoples, castes, and families are congenital and hereditary, and how far the result of education and surroundings. The distinguished President of the Anthropological Institute, Mr. F. Galton, has done much to make a beginning of the study of hereditary qualities in man, but there is still much to be done. To begin with very rudimentary facts, we hardly know whether courage in man and absence of courage in women are natural or artificial qualities; whether right-handedness is natural or a very ancient fashion. Coming nearer to modern variations we do not know how far energy, enterprise, constructive power, and all the rest of it are qualities appertaining to particular breeds, like the qualities of pointers or greyhounds; or whether they are more the result of education and surroundings. What is the effect on mind or body of vegetable and animal food respectively, and of the use of one stimulant and another? Why do particular races affect particular stimulants? Why is the Northern European more especially given to spirits, and the Chinese and Indo-Chinese races to opium? Is there anything in the breed that enables Britishers to rule over Hindus, or is it only education? Why has a Chinaman some virtues which an Irishman has not, and *vice versâ*? All through, the most important inquiry is to sift out those qualities in regard to which we must look to improvement in the breed, and those which more depend on education, so that power may not be wasted by efforts in the wrong direction—by breeding for qualities which already exist, or educating where the breed renders a particular education hopeless.

We must try to learn the direction in which we are to work first, and then the methods by which we may effect improvements in the ascertained direction—whether it be in the direction of breed or in that of education.

Now to come to the practical modes by which effect might be given to some such ideas as I have ventured to suggest.

To begin at the beginning, I think that, while so much effort and so much science have been expended, perhaps not very fructuously, in inquiries into the origin of man, too little systematic attention has been given to the radical differences between the modern man and modern animals. For instance, in the matter of speech no one can doubt that dogs and elephants and seals understand a great deal of language. One cannot see the individuals of a pack of hounds answer to their names without being satisfied that they not only attach a meaning to a few rude sounds, but can distinguish niceties and refinements of language. Again, we know that parrots and other creatures can speak our language; but I have never seen the question whether any one creature can both speak and understand thoroughly worked out. Has it been carefully and thoroughly ascertained whether any animals really cry or laugh? Sir John Lubbock and others have given attention to the question whether, in habitation-building, and the like, bees and ants exercise an intelligent discretion or follow one unvarying hereditary instinct; but I do not think any distinct conclusion has been arrived at. Can any monkey or other creature be educated up to the point of putting sticks on a fire and cooking chestnuts? I am afraid that on all these subjects there has been nothing but very desultory individual effort.

Then as regards man-breeding. Probably we have enough physiological knowledge to effect a vast improvement in the pairing of individuals of the same or allied races if we could only apply that knowledge to make fitting marriages, instead of giving way to foolish ideas about love and the tastes of young people, whom we can hardly trust to choose their own bonnets, much less to choose in a graver matter in which they are most likely to be influenced by frivolous prejudices. As I am not preaching I need say no more on that—all that I could say is self-evident. But when we come to the very important question of the crossing of races there is very great need of scientific observation and experiment. Both the general knowledge that we have of humans and the analogy of animals tends to show the great benefit of the crossing of breeds. Anglo-Saxon is an awkward term. I do not stop to inquire whether it represents two races; whether the peasant of the Lothians is an Englishman and the peasant of the south of England a Saxon, or why one is superior to the other; but using the word English for the Teutonic inhabitants of these islands I think one can hardly doubt that the English breed crossed with a dash of Celtic blood produces a better animal than either of the parent races. Witness the people of many parts of Scotland, of Ulster, and, I believe I may also say, of Cornwall. It is the use of the Celtic blood as an alloy that makes me specially unwilling to see Highlanders, and even wild Irishmen, exterminated from these islands. It may be worse for all of us if that comes to pass.

There is a popular belief that the cross between an Englishman and a Hindu produces a race inferior to either. I very much doubt the fact. Owing to the caste system (and it prevails with us almost as much as with the Hindus) half-castes are placed at a very great disadvantage, but I doubt if they are naturally inferior; at any rate, the question requires to be worked out. I think we have the means of doing so if we systematically went about it. So again as regards the cross-breeds between whites and Negroes. There is so much prejudice on the subject in the United States that it is very difficult to arrive at the truth. Some people think that the stimulating climate tends to make the white race in America wear itself out, and that (apart from the present great immigration from Europe) it would be a real improvement to the American race if the whites were crossed with the more phlegmatic blacks, say, in the porportion of six or eight of white to one of black, which now exists in the States. However, that is their affair, but a very important question for them.

And this brings me to the effect of climate. Is it the fact that in course of generations settled in America the climate alters the British race—or perhaps I should say European races? What is the tendency of the very peculiar Australian climate? It has passed into a popular proverb that the European race cannot survive in India beyond the second or third generation; and the result of that belief has been of enormous practical importance, for no sort of colonisation has been attempted. Yet I wholly doubt if the belief can be supported by any facts whatever; it is one of those things that are universally believed because they have never been tried, and therefore cannot be contradicted. Till little more than fifty years ago Europeans were not allowed to settle in India. To this day opportunities for education and good up-bringing are very much wanting—the surroundings are most unfavourable to European children; yet a good many instances could now be quoted of Europeans brought up in India who are physically just as good as their parents. The mortality in the European orphan asylums is extraordinarily low. It is not at all certain that the race might not be adapted to the climate, especially as the cool hill regions are those least occupied by the natives, and most fit for many lucrative industries introduced by Europeans.

Coming to physical and mental education, I have already alluded to some of the subjects which urgently require attention, the most important of which is, I think, the effect of what we call civilised life, and especially urban life. It is impossible to see the crowded and inferior dwellings in which so vast a population live in towns, without room for the gardens which their fathers had, and without the space and recreations natural to man, and not to fear for the result on the race. I might also say more on the question of physical education and on that of a mental education so general as to leave no mere primitive jungle plants as a stock on which to graft improved varieties; a subject which is already engaging anxious attention. On many other questions to which I have briefly alluded I might enlarge, but I have detained you so long that I think you would prefer to get to business; and so I will conclude by recommending practical anthropology to your earnest attention.

## NOTES

We have received the programme of the Finsbury Technical College for the session 1886-87. There is no change in the curriculum calling for remark.

On September 3 a banquet took place in Bologna to celebrate the 100th anniversary of the discovery of animal electricity in that city by Galvani.

The *Bund* announces that Prof. Forel, of Morges, in the Canton of Vaud, has discovered a natural gallery which goes right across the lower portion of the glacier of Arolla, in the Eringerthal, in the Valais. It constitutes a natural grotto in the heart of the glacier, and was explored to a distance of 250 metres (273 yards) by the Professor and some fellow-members of the Swiss Alpine Club from Geneva, Neuchatel, and the Canton of Vaud. The average width was from 6 to 10 metres, broadening out here and there to fully 25 metres; the height varied from 2 to 3 metres. At the spot where the party stopped, the cavern divided into two galleries, the exploration of which they reserved for another time. The glacier was found to rest direct on the ground.

According to a Kimberley journal, Dr. Holub's exploration party is making but little progress. The whole of the party had been down with the fever, which has been severe this year in the Zambezi region.

The captain of the steamer *Ardangorm* officially reports at Malta that at 1 p.m. on August 30, in clear, calm weather, when about 14 miles north of Galita, a small island between Sardinia and Tunis, he noticed that the eastern and highest peak of the island appeared to be in eruption, while smoke resembling that ascending from Mount Etna was ejected at intervals from the crater.

The *Pioneer* of Allahabad states that news dated last April has been received from Mr. Carey, who is travelling from Leh towards China. He was then at Lob Nor. His course from Leh was south-eastward into Western Tibet, and then due north to Khotan, whence he made the Tarim River. After an excursion northwards towards the Baba Kul Lake he returned to the Tarim River, and followed it to Lob Nor. He is said to have probably entered Northern China before now.

One of the projects formed by M. Paul Bert before leaving France as Resident-General in Tonquin and Annam, was the

formation of an Academy similar to that planned by Napoleon I. for Egypt. M. Bert has now issued a decree establishing the "Tonquinese Academy." The preamble sets out that it is desirable to revive in the country, which has been disturbed for so long a time, the taste for literature and science, and to preserve to the people the vestiges of its glorious past; as well as to collect the scattered evidences of its ancient splendour. The decree then goes on to provide that the seat of the Academy shall be at Hanoi, and that its functions shall be to investigate and collect everything of interest, from any point of view, relating to Tonquin, to preserve ancient monuments, to initiate the people into the knowledge of modern sciences and civilisation, by translating and publishing in the Annamite language *résumés* of European works, to translate into French extracts from the more important dynastic annals of Tonquin, as well as other works to be selected by a Commission, to aid in forming public libraries in the principal towns, and a national library at Hanoi, to publish a monthly bulletin in which scientific and other questions shall be treated, and to put itself in relations with other Oriental Societies in Europe and Asia. The Academy is to consist of forty members and an unlimited number of correspondents. The dignity of *Ham-lam* is to be conferred by the Resident-General. Various degrees are to be given to Tonquinese, and these are to be marked by a medal or emblem to be worn on the dress. Political questions are not to be discussed.

WE regret to learn that difficulties arising out of the reorganisation of the Imperial College of Engineering, Tokio, have resulted in the loss to the new University of Japan of the services of Prof. T. Alexander.

MR. R. JASPER MORE, writing to the *Times*, from the House of Commons, on the subject of "Science for the Masses," inquires why some of the 600 papers which are not read before the British Association should not be delivered as lectures at the schools or public rooms of the West Midland district, where "large and appreciative audiences would have been found, and a foundation laid for the objects of the British Association." "A few words spoken," he says, "in a familiar manner to working-men and others by members of the British Association would tend to make that taste for natural science the absence of which Sir John Lubbock deplores."

AT the last meeting of the Entomological Society of London, on the 1st inst., Mr. C. O. Waterhouse called attention to the various reports which had lately appeared in the newspapers of the discovery of the Hessian Fly (*Cecidomyia destructor*) in Britain, and inquired whether any communication on the subject had reached the Society. The Rev. W. W. Fowler stated that he had been in communication with Miss Ormerod on the subject, and that she had informed him that neither the imago nor larva of the species had been seen, and that the identity of the species rested on the supposed discovery of the pupa.

PROF. BRUN has published in the *Archives de Genève* an interesting study on the so-called lightning holes to be found in the High Alps. He and other investigators have found them at heights of from 3348 to 4000 metres, or between 11,000 and 13,000 feet above the sea-level. Usually they are found on summits. Sometimes the rocky mass, which has been vitrified in the passage of the electric fluid, presents the appearance of small scattered pearls, sometimes of a series of semi-spherical cavities only a few millimetres in diameter. Sometimes there are vitrified rays going out from a central point to a distance of 4 or 5 inches. Sometimes a block detached from the mass appears as if bored through by a cannon-ball, the hollowed passage being quite vitrified. The thickness of this vitrified coating or stratum never exceeds a millimetre, and is sometimes not more than the quarter of that depth. The varying colours which it presents depend on the qualities and composition of the rock. The same may be said as to its transparency. On the Rungfischhorn the glass thus formed by the lightning is black, owing to the quantity of actinolite which the rock contains. It is brown on La Ruinette, the rock consisting of feldspar mixed with gneiss containing chloride of iron. Under the microscope these lightning holes display many interior cavities, which must be attributed to the presence of water in the rock at the moment of melting by the electric discharge. This vitrified material has no influence on polarised light.

THE captain of the steamer *Thessaly*, belonging to the Houston Line, writing to the owners of that vessel, notes a strange experience on his last voyage from Liverpool to Monte Video. On Thursday, July 1, at 11.35 p.m., the ship, which at the time was in lat. 0° 55′, long. 29° 34′ W., was suddenly and violently shaken and bumped, the shaking being accompanied by a loud, rumbling, metallic kind of noise. The first impression was that the ship was tearing the bottom out over hard rock, but knowing there was nothing in the neighbourhood she could touch, save St. Paul's rocks, and as they could not see land, the captain concluded the machinery was going to pieces. A report received from the engine-room, however, stated that there was nothing wrong there. The engineer had slowed down instantly, under the impression that something had gone wrong. The carpenter reported the wells all free. The shock lasted about a minute; no disturbance was visible on the water. About 8 minutes after the first shock, a second, not quite so severe, stopped the ship, which in the meantime had been going slowly. Subsequently they experienced a third shock—a slight one. The lead indicated 60 fathoms with no bottom. Being now satisfied that the shocks were caused by some submarine disturbance, the captain proceeded on his course. After steaming about 15 minutes, he experienced a fourth shock, only inferior to the first in severity and duration. After this all was quiet. During the shocks the compass cards were much agitated.

WE have received a pamphlet by Prince Albert of Monaco describing the investigations which he has made during the past year in his yacht, the *Hirondelle*, into the Gulf Stream, and its relations with the coast of France. After referring to the interest which the Gulf Stream possesses for various branches of science, the Prince describes the knowledge of it possessed by the ancients, and the various investigations of modern times. The stream has been carefully studied by the Americans along their coasts, but our knowledge of it farther out in the Atlantic is more doubtful. Its influence on the French coasts has never been experimentally studied, and to this particular point the work on the *Hirondelle* was directed. 179 floats were thrown out at various places to the north-west of the Azores. These were of three classes—hollow copper balls, oak barrels, and ordinary bottles, there being ten balls, twenty casks, and 149 bottles. The various places of immersion formed a line about 170 miles in length. The conclusion which the Prince draws from the results so far is that as far as 300 miles to the north-north-west of the Azores, the Gulf Stream shows no tendency to flow towards the north-east, and even its tendency towards the east is scarcely pronounced. The pamphlet contains two charts,—one of the places of immersion of the floats, with the dates and hours, the other of the voyage of the *Hirondelle* from the time it left Lorient until its return.

THE session 1886 of the University College, Bristol, will begin on October 5. Lectures and classes are held every day and evening throughout the session. In the Chemical Department lectures and classes are given in all branches of theoretical chemistry, and instruction in practical chemistry is given daily in the chemical laboratory. Excursions to some of the

mines, manufactories, and chemical works of the neighbourhood are occasionally made. The Department of Experimental Physics includes courses of lectures arranged progressively, and practical instruction in the physical and electrical laboratory. Those students who attend the mechanical engineering course enter engineering works during the six summer months, and, in accordance with this scheme, various manufacturing engineers in the neighbourhood have consented to receive students of the College into their offices and workshops as articled pupils; the engineering laboratory is provided with a powerful testing-machine, and instruction in the use of tools is given in the workshop. Special courses in surveying are given, and excursions for field practice are frequently made. The Department for Geology, Biology, and Zoology includes various courses of lectures in all branches of those subjects, together with laboratory instruction. In the Botanical Department practical instruction is given by means of the Botanical Gardens, which contain upwards of 1000 specimens.

THE additions to the Zoological Society's Gardens during the past week include a Common Mole (*Talpa europæa*), British, presented by Mr. J. Scatcherd; two Hawfinches (*Coccothraustes vulgaris*), British, presented by Mr. W. Strutt; a Lanner Falcon (*Falco lanarius*), European, received; two Common Vipers (*Vipera berus*), British, presented by Mr. W. Robertson; a Common Viper (*Vipera berus*), British, presented by Mr. W. H. B. Pain; two Common Marmosets (*Hapale jacchus*) from Brazil, three Indian Crocodiles (*Crocodilus palustris*) from India, deposited; a Mesopotamian Fallow Deer (*Dama mesopotamica*), four Long-fronted Gerbilles (*Gerbillus longifrons*), five American Milk-Snakes (*Coluber eximus*), an Argus Pheasant (*Argus giganteus*), born in the Gardens.

## *OUR ASTRONOMICAL COLUMN*

CHANGES OBSERVED ON THE SURFACE OF MARS.—In the July number of the *Bulletin Astronomique* M. Perrotin gives a detailed account of his observations of Schiaparelli's "Canals" made during the months of April and May of the present year (NATURE, June 3, p. 110), remarking that their appearance differs little from that observed in the Milan astronomer's chart drawn in 1882, and that these markings appear to indicate the existence of a state of things, in the equatorial regions of the planet, which, if not absolutely permanent, at all events give evidence of considerable stability. But during the progress of the Nice observations of the "canals," some changes were noticed in the neighbourhood of the Kaiser Sea (Schiaparelli's Syrtis Major), which M. Perrotin has thought it worth while to put on record. During the earlier observations this part of the planet's surface was dark, like all the Martial "seas," and as it is represented in the chart. On May 21, however, the part of Syrtis Major extending from 10° to 55° of north latitude was seen to be covered with a luminous cloud forming regular and parallel bands, stretching from north-west to south-east on the surface, in colour somewhat similar to that of the continents, but not quite so bright. On the 22nd these cloud-like structures were more uniformly distributed than on the previous day; they were also seen on the three following days, but were noted to be of considerably diminished intensity. On May 25 the Nice observers noted the visibility of the isthmus which is placed in Schiaparelli's chart on the prolongation of Syrtis Major, below its junction with Nilus, in longitude 300° and north latitude 52°, and which had not hitherto been seen by them. M. Perrotin thinks it probable that these appearances are really due to clouds circulating in the atmosphere of Mars; at all events he concludes they arise from something connected with the atmosphere or with the surface of the planet capable of motion and of change in a comparatively short space of time.

A SUSPECTED NEW VARIABLE STAR.—In *Circular* No. 8 of the Liverpool Astronomical Society, Rev. T. E. Espin states that the star D.M. + 35° 4002 was observed by him on the night of June 26 last as a very red 8·5 mag. star. On August 29 it was again observed with the same comparison stars, and was found to be barely 9·5. There seems, therefore, reason for suspecting it of variation. Dunér calls this star "rouge-jaune foncé," spectrum III*b*. !!, and identifies it with Pickering No. 36 (*Astronomische Nachrichten*, No. 2376), which seems improbable, as Pickering's place is 1m. 20s. *preceding* and 0° 7′ *south*. The place of D.M. + 35° 4002 for 1885 is R.A. 20h. 6m. 3s., Decl. + 35° 36′·1.

THE BINARY STAR OΣ 234.—In the *Astronomische Nachrichten*, No. 2743, Mr. J. E. Gore publishes elliptic elements of the orbit of this binary. The components are of magnitudes 7 and 7·4, and the star has always been a close and difficult object to measure even with large telescopes. Mr. Gore considers his orbit as provisional only, on account of the discordance of some of the recorded measures. The following are the elements:—

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|---|---|
| $P = 63·45$ years | $\Omega = 124° 11′$ (1880·0) |
| $T = 1881·15$ | $\lambda = 71° 58′$ |
| $e = 0·3629$ | $a = 0''·339$ |
| $\gamma = 47° 21′$ | $\mu = + 5°·67$ |

Mr. Gore states that these elements satisfy the observations fairly well from 1844 to 1853, and from 1870 to 1880, but in the years 1858–66 the discordances are considerable. The position of the star for 1880·0 is R.A. 11h. 24m. 20s., Decl. + 41° 58′.

## *ASTRONOMICAL PHENOMENA FOR THE WEEK* 1886 *SEPTEMBER* 12–18

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

*At Greenwich on September* 12

Sun rises, 5h. 31m.; souths, 11h. 56m. 11·0s.; sets, 18h. 21m.; decl. on meridian, 4° 7′ N.: Sidereal Time at Sunset, 17h. 48m.

Moon (Full on September 13) rises, 18h. 8m.; souths, 23h. 38m.; sets, 5h. 16m.*; decl. on meridian, 6° 34′ S.

| Planet | Rises h. m. | Souths h. m. | Sets h. m. | Decl. on meridian ° ′ |
|---|---|---|---|---|
| Mercury | 4 10 | 11 9 | 18 8 | 10 46 N. |
| Venus | 3 30 | 10 40 | 17 50 | 12 53 N. |
| Mars | 10 44 | 15 19 | 19 55 | 16 46 S. |
| Jupiter | 17 27 | 13 15 | 19 3 | 3 9 S. |
| Saturn | 23 58* | 8 2 | 16 6 | 21 37 N. |

* Indicates that the rising is that of the preceding evening and the setting that of the following morning.

*Occultations of Stars by the Moon* (not actually occulted at Greenwich)

| Sept. | Star | Mag. | Disap. h. m. | Reap. h. m. | Corresponding angles from vertex to right for inverted image ° ° |
|---|---|---|---|---|---|
| 13 | $\phi$ Aquarii | $4\frac{1}{2}$ | 1 50 | near approach | 227 — |
| 13 | 24 Piscium | $6\frac{1}{2}$ | 20 33 | near approach | 168 — |
| 16 | $\nu$ Piscium | $4\frac{1}{2}$ | 7 12 | near approach | 56 — |

| Sept. | h. | |
|---|---|---|
| 18 | 21 | Venus at least distance from the Sun. |

*Variable Stars*

| Star | R.A. h. m. | Decl. ° ′ | | h. m. | |
|---|---|---|---|---|---|
| U Cephei | 0 52·2 | 81 16 N. | Sept. 16, | 19 25 | *m* |
| Algol | 3 0·8 | 40 31 N. | ,, 14, | 19 38 | *m* |
| $\zeta$ Geminorum | 6 57·4 | 20 44 N. | ,, 13, | 21 15 | *M* |
| | | | 18, | 23 6 | *m* |
| $\delta$ Libræ | 14 54·9 | 8 4 S. | ,, 14, | 2 37 | *m* |
| U Coronæ | 15 13·6 | 32 4 N. | ,, 15, | 4 2 | *m* |
| U Ophiuchi | 17 10·8 | 1 20 N. | ,, 12, | 2 55 | *m* |
| | | | and at intervals of | 20 8 | |
| $\beta$ Lyræ | 18 45·9 | 33 14 N. | Sept. 18, | 21 0 | *M* |
| $\eta$ Aquilæ | 19 46·7 | 0 43 N. | ,, 13, | 5 0 | *M* |
| | | | ,, 18, | 0 0 | *m* |
| $\delta$ Cephei | 22 24·9 | 57 50 N. | ,, 12, | 5 0 | *M* |
| | | | ,, 15, | 22 0 | *m* |

*M* signifies maximum; *m* minimum.

## THE RECENT EARTHQUAKES

THE earthquake record of the past week is a long and disastrous one. An earthquake of wide area and extraordinary intensity took place soon after 10 o'clock on the night of August 31, throughout nearly the entire portion of the United States east of the Mississippi, shocks being felt from the Gulf of Mexico northwards and from the Mississippi eastward to the Atlantic. The shocks were especially severe at Montgomery (Alabama), Cleveland (Ohio), Meadville (Pennsylvania), Raleigh (North Carolina), and Indianapolis (Indiana). In New York, Washington, Detroit, Milwaukee, Cincinnati, Louisville, Chattanooga, and other places severe undulations were felt. The shock was light at Chicago, and west of the Mississippi at Omaha, Ogden, or San Francisco no disturbance was felt. The bounds of the disturbed area are thus roughly defined to be the Mississippi, the Atlantic, the Gulf of Mexico, the Lakes and the St. Lawrence. Georgia and South Carolina appear to have been the most severely visited of all the States. At Augusta, in the former State, there were ten distinct shocks between 9.15 and 10.45 p.m., and the streets were filled with the terrified population. At Savannah five shocks were felt. Sharp shocks were also felt in New Jersey, and vibrations as far north as Philadelphia. Prof. Newcomb, of the *Nautical Almanac*, Washington, reports that the first shock occurred at 9.53.20, and the second at 9.54 30, lasting until 9.59. The Signal Service Bureau at Washington reports that four distinct shocks were felt there. The first began at 9.54, and lasted 40 seconds, the second at 10.0.4, the third at 10.10, and another at 10.30. Charleston, in South Carolina, suffered most severely, —the streets were blocked with fallen buildings, telegraph poles, and tangled wires. The population spent the night in the streets. As usual after violent earthquakes, fires broke out. The principal business quarter and two-thirds of the dwelling-houses have been destroyed, and the town was isolated from the outside world, the bridges and railroads being all destroyed. Sullivan's Island, a watering-place near Charleston, was submerged by a tidal wave. At Columbia, in the same State, ten distinct shocks of earthquake were felt, the last at 10.20 on the morning of the 1st inst. Fresh shocks were felt in the afternoon of the 1st at Augusta, Charleston, and Columbus, and during the same day throughout North and South Carolina and Georgia, and many fissures opened, emitting fresh water, white sand, and blue mud from a great depth. At 11.55 on the night of the 1st another violent shock in Charleston brought down several houses. Since that date, shocks of more or less violence have continued up to the present in the States above-mentioned.

This earthquake is believed to have disturbed a greater extent of territory than any earthquake on record. Twenty-two States, covering an area of a million square miles, were affected. Toronto and London in Ontario are said to have felt some symptoms of disturbance. The natural phenomena accompanying the earthquake are curious. The fissures in the earth, whence the sulphurous fumes arise, are not confined to Charleston itself, but are found for miles round the town. From these fissures is exuded sand, white in some places, and red in others. From other openings brackish tepid water has been spouted from 15 to 20 feet high. These fissures are not made by the sinking of the ground, but by the tearing apart of the earth's crust. Sometimes they are 20 yards long, and they are of uncertain depth. They could be seen to widen and contract during the shocks, and sand, water, and an unfamiliar substance of an oily paste character was expelled. After these ejections mound-like cones remained. The water in the wells was observed to rise and fall. At Summerville, the holiday resort of the people of Charleston, detonations were heard about once in ten minutes in all directions, but they appeared to have no relation with the earthquake shocks. There are some doubtful reports of flames being seen proceeding from the ground. The atmosphere during the earlier phenomena was oppressive, and so still was the air that the lamps burned out of doors for hours without flickering. A violent shock which visited part of South Carolina at 11 o'clock on the night of the 5th, was followed after an interval of five minutes by two brilliant meteors which shot across the sky from north to south. A curious occurrence is reported by the Correspondent of the *Times*. He says that on the 2nd inst. at Charleston "two showers of morsels of flints, abraded by mechanical action, were noticed, some having been recently fractured. The first shower fell at 7.30 a.m., and the second at 11." At the Signal Office at Washington the self-registering wind-vane shows a horizontal mark preceding and subsequent to the shaking, denoting a mild, steady, and almost invariable breeze. But during the 30 or 40 seconds of the most violent shaking, the marks indicate that the pencil point moved up and down the paper many times with great rapidity. The effect of the earthquake at sea is described by the captain of the steamer *Palatka*. He had just left Charleston, and was twelve miles off the harbour of Port Royal, in eight fathoms and a half, when he heard a terrible rumbling, lasting a minute and a half. There had been a heavy sea from the south-east, but when the rumbling began the wave-motion ceased, and the waters remained in a perfect calm until the rumbling ended, when the swell was again manifest. The wind was south-east and light, the weather cloudy, the barometer 30·01, and the thermometer at 80°. The ship's timbers vibrated strongly. No unusual meteorological conditions prevailed at Charleston before, during, or after the earthquake on the first day, according to the officer of the Signal Service. Profs. Mendenhall and M'Gee are investigating the effects of the earthquake at Charleston and Summerville.

Earthquakes are also reported from Malaga, where a severe shock occurred, on the 1st and morning of the 2nd; from Santa Cruz, in California, at 11.45 on the morning of the 2nd, where it is described as not violent, but long-continued; and from Smyrna, where several sharp shocks were felt between 10 and 12 on the night of the 31st, that is almost simultaneously with the American earthquake. A telegram dated the 5th inst., from Athens, reports that the shocks at Pyrgos have been renewed.

We have received several letters relating to the earthquake in the Eastern Mediterranean of the 27th ult. Prof. Forel, of Morges, writes that, as it extended at least from Alexandria to Berne, it covered an area of about 25° diameter. At Berne the seismograph of the Observatory marked the shock at 10h. 36m. 16s. local time, corresponding to 22h. 6m. 30s. Greenwich time. If, continues Prof. Forel, we admit, in accordance with the times recorded at Benevento, Fermo, Pesaro, and Zante, that the time of the shock at the centre was 22h. 1m. 20s. ± 70s. Greenwich time, then the seismic wave would have taken 5m. 10s. to reach Berne. It is said that the shock was felt at Alexandria 15 minutes after midnight, in which case progress in that direction was a little slower; put into Greenwich time, this would be 22h. 15m., or about 14m. for transmission from Zante to Alexandria. In Switzerland a small preparatory shock was felt in the Alps of Vaud, about 11 minutes before the Berne shock. Mr. Henry Simon, writing from Engelberg, in Obwalden, states that the shock was distinctly felt there as a swaying motion about 10.20 by several of the visitors and in different houses.

## THE SCOTTISH METEOROLOGICAL SOCIETY

THE following is an abstract of the Report of the Council read at the meeting of the Scottish Meteorological Society held on July 22:—

Since the general meeting of the Society in March, the number of the Society's stations has remained the same.

The membership of the Society now numbers 719, being 7 more than at the meeting in March.

The preparation of a fourth paper on the climate of the British Islands, dealing with the monthly rainfall for the twenty years 1866-85, is now far advanced, and the results are practically and scientifically of great interest.

Much time has been spent in preparing for the press the whole of the observations of the Ben Nevis Observatory and those of the station at Fort William for the two years and a half from December 1883 to May 1886. The volume will shortly be in the hands of scientific men in all parts of the world. In connection with these valuable observations, the investigation of the important question of the bearing of the results on the weather of these islands is steadily advancing.

The position of the Ben Nevis Observatory on an elevated isolated peak, and the adjoining low-level station at Fort William being close to the sea, and on a bank sloping down to it, renders this pair of stations second to none anywhere yet established for the investigation of some of the fundamental facts of meteorology. Among the more important of these questions is the determination of the rate of decrease of temperature with height, and the rate of diminution of atmospheric pressure with height, for different atmospheric temperatures and sea-level pressures.

In these aspects the observations for the two years and a half from December 1883 to May 1886 have now been discussed. As regards decrease of temperature with height, it is shown to be at the rate of 1° F. for every 270 feet of ascent—a rate which closely agrees with the results of the most carefully conducted balloon ascents, and of those other pairs of stations over the world which are so situated as to yield trustworthy results for the inquiry. Ben Nevis Observatory and the Fort William station are among the very few such groups of stations that have yet been anywhere established.

In researches into weather phenomena and weather prognostics the most important point to determine is the normal difference between atmospheric pressure at the top of the Ben and at Fort William for the different atmospheric temperatures and sea-level pressures. This was empirically calculated from the observations, and thereafter the departures from the normals were ascertained for the five observations of each day since the Observatory was opened. The results showed a diminution of pressure from the calculated normals during the occurrence of high winds at the Observatory. The difference not unfrequently amounts to the tenth of an inch, and on one day the five consecutive observations showed differences of about a tenth-and-a-half inch. This diminution of pressure is doubtless occasioned by the winds, as they brush past the Observatory buildings, partially sucking out the air from the interior, thus lowering the pressure. This does not occur till the velocity rises to or exceeds the rate of 30 miles an hour.

It thus became necessary to recalculate the normals for pressure, using in the computations only those observations which were made when the velocity of the wind fell short of 30 miles an hour. This recalculation has recently been completed, and the inquiry as to the bearing of the Ben Nevis observations on the weather of the British Islands is being pushed forward.

The work at the Ben Nevis Observatory continues to be discharged by Mr. Omond and his assistants in a way that leaves nothing to be desired. Since the last meeting of the Society Mr. Omond has contributed a valuable paper to the Royal Society of Edinburgh, on the observations of wind force recorded at the Observatory. From a comparison of the results obtained from the registrations of Prof. Chrystal's anemometer, and the estimations of the force of the wind made by the observers on scale 0 to 12, he has determined the velocity in miles per hour for each figure of the scale, 1, 2, 3, &c. The highest figure for which the double observations were sufficiently numerous, so as to give a good average, was 8, which was found to be equivalent to a rate of 73 miles an hour. This velocity is of frequent occurrence; and as regards the higher force 11, which occasionally occurs, Mr. Omond estimates its equivalent at 120 miles an hour. Observations on the rain band have been undertaken by Mr. Rankin, the first assistant.

The hygrometric observations made by Mr. H. N. Dickson at the Scottish Marine Station and the Observatory have now been partially discussed by him, and the results submitted to a recent meeting of the Royal Society of Edinburgh. These results are of considerable value in determining how far Glaisher's factors, so largely used by meteorologists in hygrometric inquiries, may be used satisfactorily. As regards the remarkably dry states of the atmosphere, which are so prominent a feature in the climate of the Ben, Glaisher's factors are altogether inapplicable, and hence the hygrometric observations of the Observatory, therefore, will require a specially constructed set of tables.

The zoological work at the Marine Station has been carried on regularly. The principal work since March last has been the examination of the ova and larvæ of fishes. Endeavours have been made to obtain the early stages of as many species as possible, and as only a few species breed at one season, considerable success has been achieved. The results of this work have been communicated to the Royal Society.

Since the last meeting the Physical Department of the Scottish Marine Station has been actively engaged in carrying on observations of temperature and water-density in the Firth of Forth and the Clyde districts. Meteorological observations are continued at Granton, and the temperature of a number of rivers (the Thurso at three points, the Tummel, Forth at two points, Teith, Tweed, and Derwent) is being observed daily. Mr. Morrison has continued his monthly trips to Loch Lomond and Loch Katrine, where he has observed the vertical distribution of temperature. The work on the Firth of Forth, usually carried on solely by serial temperature observations made on the *Medusa* inside the Isle of May, has been supplemented by the captain of one of the Granton steam-trawlers, who was supplied with a deep-sea thermometer, and has been using it to good purpose in the North Sea from 30 to 60 miles off shore. The tidal variations of salinity in the estuary of the Forth were investigated by Dr. Mill and Mr. Morrison during a week's stay at Kincardine, and the result embodied in a paper read to the Royal Society of Edinburgh. Two trips of the *Medusa* on the Clyde supplied data for a paper which is presented to this meeting, as well as a quantity of observations not yet fully worked up.

The work of collecting and discussing the sea temperatures around the coast of Scotland is being carried on by Dr. Mill and Mr. Morrison. Since last meeting the Meteorological Council of London has lent all the sea observations made at the Scottish Coast-Guard Stations from 1879 to 1885; and observations of river temperature made by direction of the Duke of Sutherland and Mr. Boyd, Peterhead, have also been received. The Government Grant Committee of the Royal Society of London has given a grant of 50*l*. towards the completion of this work. Thermometers have been lent for use in the deep water off Shetland to Mr. F. Coulson, who is at present on a dredging trip in his yacht in that locality. The National Fish Culture Association of England, which has been in correspondence with the station for some time as to physical observations, has now commenced operations at several light-ships and on board the mission-smacks in the North Sea.

Mr. John Murray, of the *Challenger* Expedition, made a communication on the extent of the areas of the different mean annual rainfalls over the globe. He had been led to undertake this inquiry so as to find out the amount of material carried down from the land to the ocean, and which went to form ocean deposits. The amount of rain that fell upon the surface of the globe annually was estimated at about 34,000 to 35,000 cubic miles. Taking the inland drainage areas disconnected with the sea, such as the Sahara Desert, it is found that 77 cubic miles of rain fell upon these surfaces, which must be regarded as equivalent to the amount of evaporation. The Americans had calculated that 99 million millions of cubic feet of rain fell annually over the Mississippi drainage area. Calculating the outflow of the river, they estimated that only one-fourth of that water reached the ocean. By extending their inquiry over large areas, it was hoped that it would be made of some practical importance.

Dr. H. R. Mill, of the Scottish Marine Station, read a paper on the temperature of the water in the Firth of Clyde and its connected lochs. The configuration of the water system was explained by means of a bathymetrical chart. Roughly speaking, the Firth of Clyde contained two tracts of deep water—one in which the water is over 70 fathoms deep, running up Kilbrannan Sound, and the other rather deeper between Arran and Ayrshire—uniting with the first at the north of Arran, and continuing up Loch Fyne to near Ardrishaig, attaining its greatest depth off Skate Island, near Tarbert, where it is 107 fathoms. These tracts of deep water are separated from the Atlantic by a broad plateau, which extends between the Mull of Cantyre and Girvan, and rises to within 25 fathoms of the surface. There are also three shallow lochs—Gareloch, Holy Loch, and Loch Ridden; and four deep lochs—Upper Loch Fyne, Loch Goil, Loch Strivan, and Loch Long—which are shut off from communication with the outside waters by barriers rising in some cases to within a few fathoms of the surface. Dr. Mill then gave an account of the temperature in each of the regions as were ascertained during trips of the *Medusa* in April and June. He omitted, he said, discussing in detail the individual observations until fuller investigation gave the data for a general theory. In April, surface temperature over the whole Clyde district varied only from 42° to 45°, and the temperature at considerable depths had a range of not more than half a degree—41°·3 to 41°·8. The warmest water was found on the barrier plateau at the south end of the firth, and outside it, the deep lochs came next, and then the deep open basins. In all cases the temperature fell gradually, proceeding downwards for about 10 or 15 fathoms, and then remained constant to the bottom. By June a considerable heating of the surface-layers had taken place, and the different regions had undergone changes to a very different extent. The shallow lochs had been heated apparently from the surface and from the bottom; the greatest rise in temperature was found beyond the plateau, then in the deep open basins, and the least in the deep lochs, one of

which, Loch Goil, was only half a degree warmer than in April. The range of surface temperature in June was from 45° to 53°, and of bottom temperature from 42° to 47°·3, according to locality. Constant temperature to the bottom commenced at a much lower depth than in April. In the upper basin of Loch Long, which was discussed with more fulness, the surface-temperature was 48°·4, at 10 fathoms it was 44°·2, and from 55 fathoms to the bottom at 70 fathoms it was 44°. But between 10 fathoms and 55 fathoms the water was colder than at either of these points, reaching its lowest temperature of 42°·8 at 20 fathoms. It thus appeared that a lenticular mass of water floated between the warmer strata, the opinion as to the cause of which was meantime reserved until further light can be thrown on the phenomenon. In the Clyde district, Dr. Mill said, physical configuration is the determining cause of differences of temperature, and it appears that as the season advances, warmth descends from the surface everywhere by conduction, and travels inward from the sea by conduction and convection. The study of water climate, he said, was likely to lead to important results, but it must be carried on by a large number of observers, who would note the temperature of rivers and of falling rain, before any degree of completeness could be obtained. The paper was illustrated by a series of admirable charts.

## *SCIENTIFIC SERIALS*

THE *Journal of the Franklin Institute*, August.—Capt. O. E. Michaelis, the applications of electricity to the development of marksmanship. This is the conclusion of an interesting paper on chronoscopic and chronographic methods, illustrated by cuts of recent instruments.—W. Lewis, experiments on transmission of power by gearing (conclusion of the discussion).—F. Lynnwood Garrison, the microscopic structure of car-wheel iron.—G. Richmond, the refrigeration-machine as a heater.—C. Hoele, a method of designing screw propellers.—F. E. Ives, correct colour-tone photography with ordinary gelatine bromide plates. A proposal to reduce the sensitiveness of the bromide films to the blue and green rays, by introducing into a plate-glass tank mixtures of aniline colour solutions, chiefly yellow and red, in certain proportions, thereby equalising the sensitiveness throughout the range of the visible spectrum.—Joshua Pusey, suggestions towards a simplified system of weather signals, termed the index weather-signal system.—P. E. Chase, Herschel and Jevon on density of the ether.

*Annalen der Physik und Chemie*, vol. xxviii. No. 8, August 1886.—Prof. G. Quincke, electrical researches, No. xii., on the properties of dielectric fluids under strong electric forces. The dielectric constant of a number of liquids is examined by two methods, by attraction between two plane parallel plates immersed in the liquid, and by discharge of their charges through a galvanometer. High potentials were obtained by a Holtz machine, and measured by a long-range electrometer up to 30,000 volts. The results show that with high electric forces the dielectric constant is less than with lower electric forces; in other words, there exists an apparent tendency to saturation in inductive capacity. Measurements of the dielectric constant are always from 10 to 50 per cent. higher when made by the balance-method than those made by the condenser discharge method. In different dielectric fluids the spark-distance for the same difference of potentials is different, and always much shorter than in air. The potential requisite to produce a spark within a dielectric liquid increases with the spark-length, but at a slower rate. The strength of a steady electric current in a dielectric fluid increases more rapidly than the electromotive force which produces it; an exception, apparently, to Ohm's law.—L. Sohncke, electrification of ice by water-friction. Experimental proof that water becomes negatively electrified and ice positively electrified by mutual friction. The author thinks thereby to explain the origin of thunderstorms by friction of cumulus and cirrus clouds.—E. Edlund, researches on the electromotive force of the electric spark. He finds the counter-electromotive force of the electric spark to be divisible into two parts, one at each pole, that at the positive pole decreasing, and that at the negative pole steadily increasing, as the air-pressure is diminished. He regards this as explaining the anomalies of unequal heating of the electrodes.—W. Donle, contributions to knowledge of the thermo-electric properties of electrolytes. According to these experiments the thermo-electromotive force between two electrolytes, such as solution of sulphate of copper and sulphuric acid is approximately proportional to the differences of temperature of the points of contact; the proportionality varying in some way with the concentration of the solutions. The electromotive force is usually less with more concentrated solutions. Through the heated junction of a chloride and a sulphate the current flows from chloride to sulphate.—F. Auerbach, on the electric conductivity of metal powders. Precipitated silver was used. The author finds an enormous reduction when the density is increased by mechanical force.—R. Krüger, on a new method of determining the vertical intensity of a magnetic field. This method consists in sending an electric current radially through a horizontal copper disk suspended by a thin wire, and observing the rotation of the disk.—R. Maurer, on the ratio of the sectional contraction to the longitudinal elongation produced in rods of glue-jelly. The rods were made of gelatine and water, and of gelatine and glycerine. One of the methods was an electrical one, consisting in observing the change of electrical resistance on stretching. These jelly rods exhibit the phenomena of residual strains very markedly.—M. Hamburger, researches on the duration of the impact of cylinders and spheres.—Dr. K. Noack, on the fluidity of absolute and diluted acetic acids. Curious minima of fluidity are observed by the author, varying with concentration and with temperature.—W. Müller-Erzbach, the law of decrease of absorbing power with increasing distance.

## *SOCIETIES AND ACADEMIES*

### EDINBURGH

**Royal Society**, July 19.—Mr. Robert Gray, Vice-President, in the chair.—The Right Hon. Lord Rayleigh communicated a paper on the colours of thin plates. He has laid down on Maxwell's triangle of colours a curve representing the variation of the colours of thin plates as the thickness of the plates increases.—Prof. Dr. Fr. Meyer communicated a paper on algebraic knots.—Prof. Tait described Amagat's "manomètre à pistons libres."—Prof. C. G. Knott communicated a paper on the electrical properties of hydrogenised palladium. This paper contains the results of experiments on the resistance and thermo-electric properties of hydrogenium or hydrogenised palladium. Up to a temperature of about 200° C. no special peculiarity is noticeable; but at that temperature, or a little higher, hydrogen begins to escape from the wire, and this causes the particular specimen of hydrogenium to recover partially, if not wholly, its pure palladium characteristics. It is known that the resistance of a palladium wire charged with hydrogen at ordinary atmospheric temperatures increases at a rate almost strictly proportional to the amount of charge. The same law seems to hold at all temperatures up to 150° C., and in such a way that the *total* increase of resistance of a given palladium wire for a given rise of temperature is nearly the same at all charges; or the temperature-coefficient for any particular specimen of hydrogenised wire is practically inversely proportional to the resistance as compared with the resistance of the wire in its pure uncharged state. Just before the hydrogen begins to escape, the resistance begins to increase somewhat more rapidly than at lower temperatures; and this peculiarity is more marked in the specimens of higher charge. When once the hydrogen begins to escape, the resistance begins to fall off rapidly as the temperature rises to 300° C. At this temperature the wire cannot be distinguished from pure palladium. In the thermo-electric experiments, peculiar irregularities appear at the higher temperatures, which seem to be due to the fact that the hydrogenium wire is unequally heated, and that the hydrogen, which is almost completely driven out of the heated portion of the wire, returns partially as the wire is cooled down again. In all cases at temperatures below 150° C., the current is from pure palladium to hydrogenium through the hot junction, is probably proportional to the difference of temperature in each case, and is greater for the greater charge. Thermo-electrically, fully saturated hydrogenium lies between iron and copper at ordinary atmospheric temperatures. On the thermo-electric diagram the hydrogeniums of different charge are represented (up to a temperature of 150° C.) by a series of straight lines parallel to palladium, whose thermo-electric powers at 0° C. range roughly from − 600 (pure palladium) to + 1400 (saturated hydrogenium) expressed in C.G.S. units. (Compare Everett's "Units and Physical Constants," p. 151.)

In other words, the electromotive force in a circuit of palladium and saturated hydrogenium, the temperatures of the junctions being $0°$ C. and $100°$ C., is $20 \times 10^4$ C.G.S. units, or ·002 volts. The thermo-electric peculiarities of hydrogenium may be prettily shown by the following simple experiment. Let a palladium wire, by immersion to half its length in the electrolytic cell, be hydrogenised throughout that half length. Attach the ends of this seeming single uniform wire to the terminals of a galvanometer, and let a flame be allowed to play gently at the central point of the wire. A large current is at once obtained, which grows to a maximum, and then diminishes to zero as the temperature rises to a red heat. There is no such current during cooling. This spurious neutral point is due to the hydrogen being driven out of the heated portion, partly, no doubt, into the contiguous colder portions. By following up with the flame the ever-shifting point of separation between the charged and uncharged portions, we may repeat the experiment indefinitely until the hydrogen is all driven out of the wire, or until the distribution of hydrogen has become fairly uniform.—Mr. Thomas Andrews communicated a paper on the electro-chemical reactions between metals and fused salts.—Mr. H. N. Dickson communicated a paper on the hygrometry of Ben Nevis and the Scottish Marine Station.—Mr. J. T. Morrison read a paper on the temperature of Loch Lomond and Loch Katrine during winter and spring; also, a note on the surface temperature near a tidal race.—Mr. John Aitken gave further remarks on dew.—Prof. J. B. Haycraft gave a communication on the nature of the objective cause of sensation.

### Sydney

**Royal Society of New South Wales**, July 7.—H. C. Russell, F.R.A.S., in the chair.—The following papers were read:—Further additions to the census of the genera of plants hitherto known as indigenous to Australia, by Baron Ferd. von Müller, K.C.M.G., F.R.S. The author gives the number of Australian plant-genera recorded hitherto as 2248.—Notes on improvements in the construction of reflecting telescopes by hand, and experiments with flat surfaces, by Mr. H. F. Madsen. The author showed an 18-inch speculum, and the glass tool with which it was worked. The latter was composed of three plates of 1-inch rough glass cemented to form a solid block, and worked to about one-quarter more convexity than the required concavity of the speculum, which was partly hollowed out at first by a leaden weight and emery. The speculum-glass was then ground by hand over the block, the two forming themselves into perfectly spherical surfaces having a high reflective power, and free from irregularities of less than 1/50,000 inch. The speculum, having now an absolutely true surface, was polished with emery upon pitch, it being uppermost, and moved round without pressure. The pitch-polisher had an improved graduation, the result being that, without side motion, the speculum was polished by hand for hours without producing the trace of a ring. Both polisher and glass having been regularly raised in temperature, were left together until cool, when ten minutes was required to give the true parabolic curve, the glass being simply revolved on the polisher, great care being taken to avoid the slightest inequality in temperature. Without the aid of machinery, it is doubtful if larger specula than 18-inch could be produced by hand. Mr. Madsen investigated the thickness of the silver film of a speculum by a novel optical method, and confirmed the late Dr. Draper's "chemical" estimate, viz. 1/200,000 inch. Two perfectly flat surfaces 5 inches diameter were taken and illuminated by a homogeneous yellow light of 1/44,000 wave-length, falling at an angle of $30°$ incidence (Brashear's colour-test), whereby a series of straight dark and coloured bands were visible. By silvering half the upper surface of one of these glasses the bands were displaced or broken at the edge, a distance of about $2x$ ($x$ being the distance between two succeeding bands). The thickness of silver, $\delta$, would be expressed by

$$\frac{\lambda\ \text{(wave-length)}}{5} \sec 30 = 0\cdot00000525.$$

Several measurements gave less than 1/300,000 inch. Under the same optical methods the effects of heat and cold were rendered plainly visible and measurable. The true surfaces were placed on a 2-inch diameter wooden chuck; the light falling at $65°$ gave a uniform colour. On applying the finger without pressure upon the centre of the top glass, the colour changed to regular concentric rings, causing the glass to become concave by a measurable quantity. Placing the glass upon an iron support produced convexity (1/30,000 inch) in a regular curve. With a pressure of 8 lbs. on the centre, two wide bands of colour appeared, crossing in the centre, straining the glass in two directions, and destroying its figure. These experiments show how the defining power of specula and lenses is injured by temperature.

### Paris

**Academy of Sciences**, August 30.—M. Émile Blanchard in the chair.—In the name of the Academy the President felicitated M. Chevreul on his hundredth anniversary, remarking that the case was unique in the annals of the Academy; even Fontenelle, although spoken of as a centenarian, having died shortly before reaching that venerable age. M. Chevreul replied with a few touching words of gratitude for the sympathy of his *confrères*, after which a telegram was read from the University of Kasan complimenting the patriarch of the scientific world on his long and laborious life, so fruitful in valuable contributions to the progress of the technical arts.—On a remarkable case in the problem of planetary perturbations, by M. F. Tisserand. In the case of two planets revolving round the sun, or of two satellites round their planet, in orbits slightly inclined towards each other, it is shown that even if the proper excentricity be null there may be a very sensible apparent excentricity. In other words, if the movement of one orb was originally circular and uniform, the perturbations caused by the other would transform this movement into one approximating to a Keplerian elliptical orbit with a uniform rotation of the long axis. These results are compared with those obtained by A. Hall and S. Newcomb for the Saturnian satellite Hyperion, in so far as its movement results from the perturbations caused by the larger satellite Titan.—On the atomic weight of germanium, by M. Lecoq de Boisbaudran. The atomic weight of this body, provisionally determined by M. Winkler at 72·75, and by the author theoretically at 72·28, is now found by M. Winkler to be 72·32. The law of proportionality between the variations of the atomic weight and those of the wave-lengths, a law already applied to gallium, here receives a fresh and important confirmation. It becomes at the same time highly probable that no appreciable error now exists regarding the atomic weights of cæsium, rubidium, potassium, indium, gallium, aluminium, tin, and silicium. In fact the wave-lengths and atomic weights of Cs, Rb, K, In, and Al have served to calculate spectrally the atomic weight of gallium (afterwards verified analytically), while the $\lambda$ and atomic weights of In, Ga, Al, Sn, and Si have helped to determine spectrally the atomic weight of germanium.—Note on a reptile of the Permian formation, by M. Albert Gaudry. To this reptile, which was found by M. Bayle in the Permian beds of Télots, near Autun, the author proposes to give the name of *Haptodus baylei* (from ἅπτω and ὀδούς), the teeth adhering so closely to the maxillaries as at first sight to be scarcely distinguishable from them. In these rocks, where no animals higher than fishes were for a long time known to occur, there are now found four distinct types of Reptilia: Actinodon, Protriton, Stercorachis, and Haptodus.—Phosphorography applied to the photography of the invisible, by M. Ch. V. Zenger. Observing Mont Blanc after sunset in September 1883, the author noticed that the blue-greenish glow remained perceptible till 10.30 p.m.; hence he concluded that the ice on the summit mingled with carbonate of lime emitted a light like that of Lake Geneva, and that it might be possible to fix the image of the mountain at night by means of the phosphorescent light of the ice, which is highly actinic. On his return he projected the images given by the photographic lenses in the dark chamber on a glass plate covered with a layer of Balmain's phosphorus, just as such plates are prepared with collodion. After exposing it for a few seconds, he removed it in the dark from the chamber in order to place it in contact with a not very sensitive dry photographic plate. After an hour of contact in the dark, the image of the object appeared in all its details as in an ordinary case of photographic impression. Subsequent experiments tended to show that light may be absorbed, and afterwards slowly given back, and that images of objects invisible in the dark may be fixed by simple contact, or by the photographic apparatus. He found it useful to cover the plates with chlorophyll, as when thus prepared they become sensitive to all the radiations of the solar spectrum from the ultra-red to the ultra-violet.—Observations of Winnecke's comet made at the Obser-

vatory of Algiers with the 0.50 m. telescope, by M. Ch. Trépied. On August 23 the apparent position of this comet was :—

| Algiers mean time. | | Apparent Right Ascension. | | Log. fact. parall. | | Apparent Declination. | | Log. fact. parall. |
|---|---|---|---|---|---|---|---|---|
| h. m. s. | | h. m. s. | | | | ° ′ ″ | | |
| 8 4 29 | ... | 13 21 11·65 | ... | 1·656 | ... | − 3 2 31·8 | ... | 0·731 |

—On some non-linear differential equations, by M. Roger Liouville.—On the algebraic integrals of the problems of dynamics, by M. G. Kœnigs.—Notes were submitted by M. Martin on an apparatus reproducing the motions of the heavenly bodies, and by M. L. Hugo on the geometrical forms of the hailstones which fell in Paris on August 23.

### Berlin

**Chemical Society**, July 26.—C. Liebermann, President, in the chair.—S. Gabriel has further examined isoquinoline obtained by the reduction of monochlorisoquinoline; it melts at 20°. He has also prepared some new derivatives of dichlorisoquinoline.—Biedermann has prepared some derivatives of para-hydroxybenzylalcohol.—Kaschig communicated a very interesting research on the nature of gold chloride. He has prepared nitrogen compounds corresponding to the three oxidation stages of gold, and these he has analysed by a new method; he points out the analogy between the iodides of nitrogen and gold fulminate and the analogous compounds obtained from gold chlorides and methylamine.—Prof. Pinner reported on the following communications received by the Society:—Clève, on naphthalenesulphonic acids and on the value of orientation determined with the help of phosphorus pentachloride.—P. Bradley, on thienylglyoxylic acid and its derivatives.—R. H. Mertens, on the nitration of di- and mono-methylaniline with dilute nitric acid.—R. Leuckart and E. Bach, on the action of ammonium formate on benzaldehyde and benzophenone; bases are produced, that from benzophenone having the composition $\begin{matrix} C_6H_5 \\ C_6H_5 \end{matrix}\!\!>\!CH.NH_2$. Camphor also reacts with ammonium formate with production of crystalline compounds which, however, have not yet been further examined.—T. H. van't Hoff and Ch. M. von Deventer have studied the question of the temperature at which reaction takes place in chemical decomposition and the accompanying phenomena: first in the case of double salts, *e.g.* sodium ammonium racemate or copper calcium acetate; and secondly in the case of double decomposition, *e.g.* the decomposition of magnesium sulphate and sodium chloride with formation of astracamite and magnesium chloride, the reaction temperature in this case being 31°.—B. Tollens describes what he considers the best method for preparing formaldehyde.—Werner Kelbe and H. Stein have a paper on the products of the action of bromine on aqueous solutions of xylenesulphonic acids.—H. von Perger gives a preliminary account of the results obtained from the action of ethyl acetoacetate and ethyl acetonedicarboxylate on hydrazo-compounds.

### Stockholm

**Geological Society**, May 6.—Baron Nordenskjöld gave an account of his researches on the atomic weights of certain rare terrestrial metals, pointing out the peculiar conditions under which they combine in some minerals. He further described the analyses of the dust which had fallen in 1883 in the Cordilleras, believed to be of cosmic origin, being connected with the much-discussed red glows in the autumn of that year. Baron De Geer expressed the opinion that the glow was a natural meteorological phenomenon, though very pronounced in 1883, whilst Prof. Brögger sided with the usual view of its being caused by the Krakatão eruption.—Dr. E. Svedmark exhibited a map of the district of Roslagen, near Stockholm, showing the lakes and valleys which were considered to be caused by the cracking of the earth's crust. He also corrected the reported discovery of basalt at Tolånga, in the province of Scania, which on closer examination had been found to be diabase accompanied by the formation of tophus.—Dr. F. Svenonius read a paper forwarded by Dr. H. Sjögren, on the mud volcanoes in the neighbourhood of Baku, in which locality he has for a long time sojourned, in order to prosecute geological researches. The volcanoes occur in a line along the Caspian Sea some 120 miles in length. One of the greatest mud cones as 1000 feet high, and the crater 2100 feet in diameter, viz. almost equal to that of Etna. Three violent eruptions have taken place this and last year. They were accompanied by severe emissions of fire, as, for instance, once by a column of are 50 feet in height, visible at a distance of 80 versts. There are also violent discharges of gas, which on one occasion, on being fired, produced a fire-column 20 feet in height. The discharge was so violent that the current could only be fired at a height of 7 feet from the opening. The changes which the surrounding rocks and mountains had suffered through the influence of these volcanoes were of the greatest interest.

## BOOKS AND PAMPHLETS RECEIVED

"Journal of Society of Telegraph Engineers," Nos. 62 and 63: List of Members (Spon).—"Pictorial Arts of Japan," part 3, by W. Anderson (S. Low and Co.).—"The Mulberry Silkworm," by C. V. Riley (Washington).—"Record of North American Invertebrate Palæontology for 1885," by J. B. Marcou (Washington).—"A List of the Mesozoic and Genozoic Types in the Collections of the U.S. National Museum," by J. B. Marcou (Washington).—"Proceedings of the American Academy of Arts and Sciences," October 1885 to May 1886 (Boston).—"Memoirs of the Geological Survey of India," vol. i. 3. "The Fossil Echinoidea." Fasc. vi. "The Fossil Echinoidea from the Makran Series (Pliocene) of the Coast of Bilūckistán and of the Persian Gulf," by P. M. Duncan, and W. P. Sladen (Trübner).—"University College, Bristol: Calendar for the Session 1886-87" (Arrowsmith, Bristol).—"Durham College of Science, Newcastle-on-Tyne: Calendar for the Session 1886-87" (Reid, Newcastle).—"University College, Dundee: Calendar for the Fourth Session 1886-87" (Lang and Co., Dundee).—"Analysis Tables for Chemical Students," by R. S. Taylor (S. Low and Co.).—"Exercises on Mensuration for Junior Students," by T. W. K. Start (S. Low and Co.).—"The Methods of Glass-Blowing," by W. A. Shenstone (Rivingtons).—"First Lessons in Zoology," by A. S. Packard (Holt and Co., New York).—"Fancy Pigeons," parts 11, 12, 13, by J. C. Lyell (U. Gill).—"British Cage Birds," parts 11, 12, 13, by R. L. Wallace (U. Gill).—"Loggio di Igiene Antimicrobica," by I. Giglioli (Napoli).—"Journal of the Chemical Society," September (Van Voorst).—"Thèses à la Faculté des Sciences de Paris," 1 and 2, by J. Deniker (Poitiers).—"Goolden and Trotter's Dynamos," 4th edition.

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